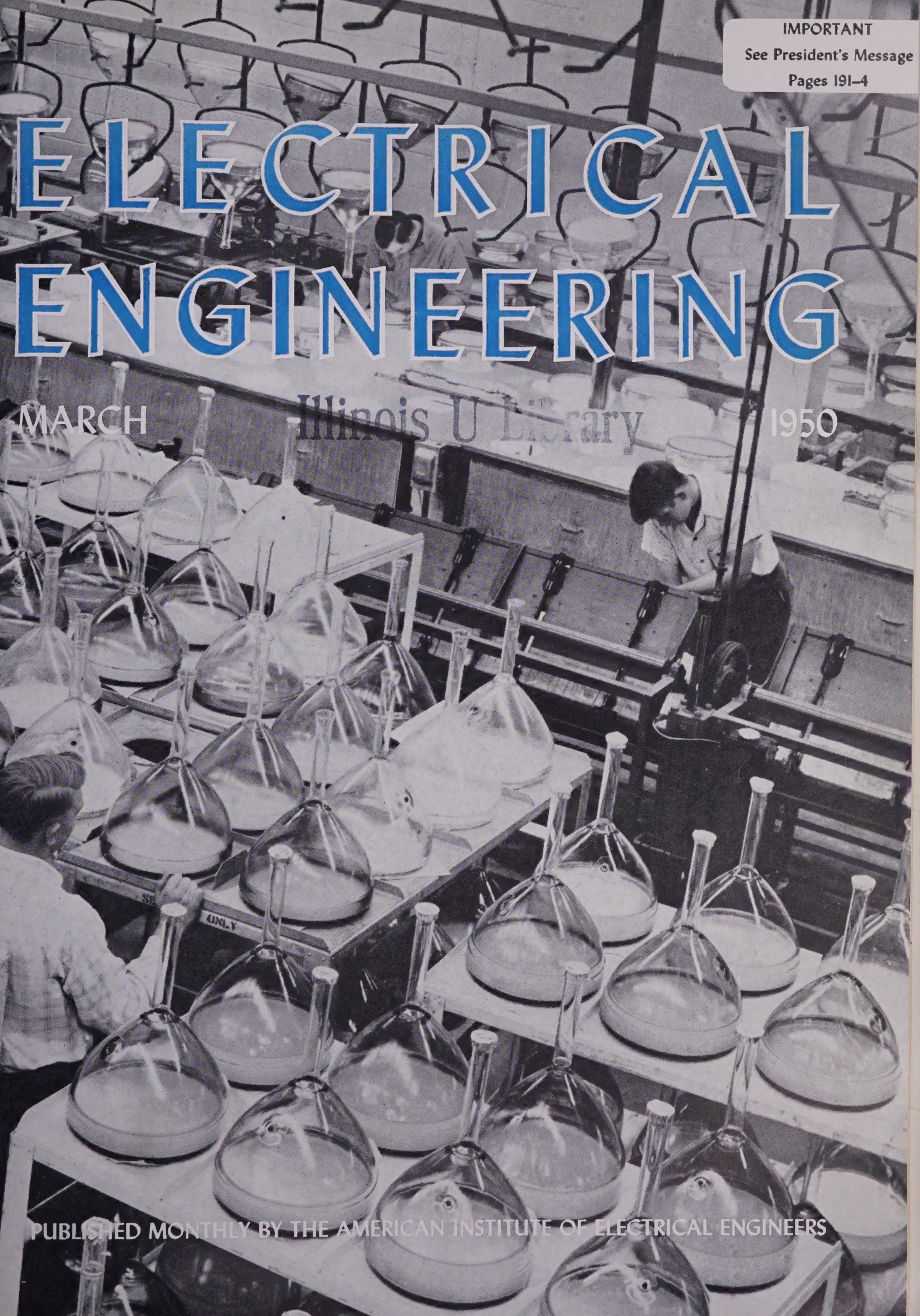
IMPORTANT
See President's Message
Pages 191–4

ELECTRICAL ENGINEERING

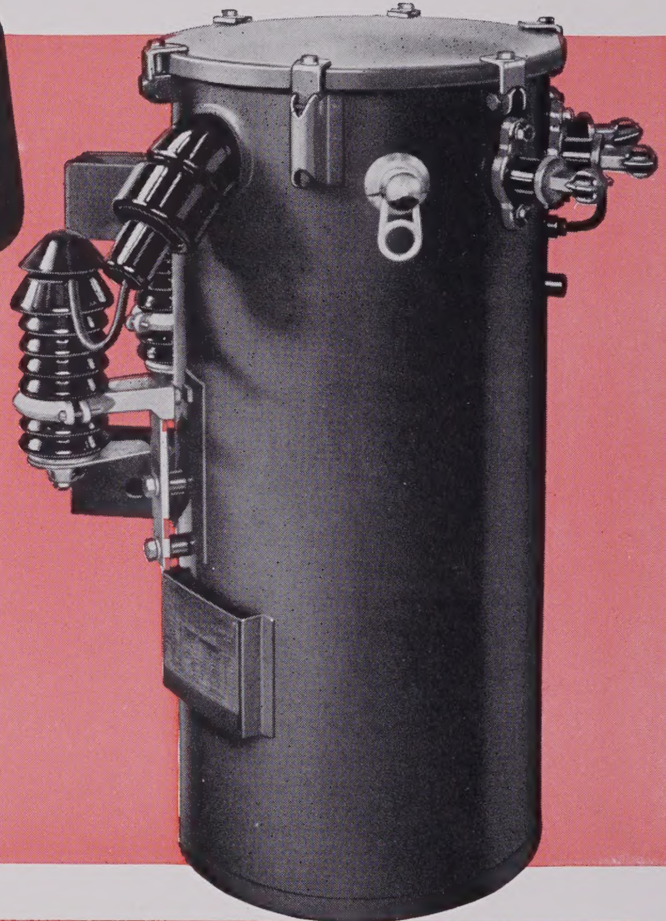
MARCH 1950



PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

HERE'S WHAT WE MEAN BY *Premium* PROTECTION

...on ACP* Transformers



1. CIRCUIT BREAKER protects against all secondary overloads and short circuits . . . fully utilizes short time overload capacity of transformer.

2. LIGHTNING ARRESTERS externally mounted provide overvoltage protection . . . expulsion or valve types.

3. BREAKER RESET HANDLE provides safe, easy means of energizing load.

4. SIGNAL LIGHT indicates when transformer has entered into the maximum safe operating band . . . stays lit to provide visual check on loading.

*Allis-Chalmers Protected *ACP* is an Allis-Chalmers trademark.

WHEN YOU INVEST in transformer protection — and want the *best* — specify ACP transformer *premium* protection.

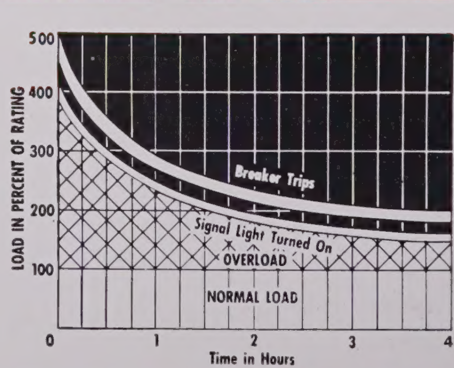
Secondary breaker, high voltage protective links and lightning arresters are coordinated to give full electrical protection. Transformer and protective equipment are completely packaged to give you reduced installation costs, simplified stocking.

For details on premium protected ACP transformers, contact your nearby A-C sales office. Or write direct.

A-2945

How ACP Transformer Utilizes Overload Capacity

Breaker is actuated by either excess load current, oil temperature, or both. Coordination of these elements with thermal characteristics of transformer puts overload capacity to work (see typical curve for ACP transformer at right).



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ELECTRICAL ENGINEERING

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MARCH 1950

The Cover: Inspection station under a conveyor line at the Ottawa, Ohio, picture tube plant of Sylvania Electric Products Inc. In foreground fluorescent coating is being settled out, while operator in background checks the coated tube faces.

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VOL. 69 NO. 3

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

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New York 18, N. Y.

THE BIDDLE Impulse Cable Fault Locator AND D-C PROOF TESTER

—A High Voltage D-C Impulse Transmitter with Pickup Coil and Pointer-Indicating Detector

The Model 2-2 Fault Locator, here illustrated, is rated up to 20 kv. with a discharge capacitance of 2.5 muf. It is for use on all cable up to 15 kv. and higher. Requires only about 500 watts to operate, from a 115-volt lighting circuit. The transmitter can be used independently as a source of high voltage D-C for proof testing on all types of electrical equipment.

Designed primarily for locating faults on lead-covered cable installed in ducts, this *NEW* equipment has applications also on aerial and buried cable, and has proved highly effective in utility and industrial service. In operation, the set is essentially independent of the type of fault or its apparent resistance, and depends only on the impulse voltage required to break down the fault.

The BIDDLE Impulse Cable Fault Locator was developed on the property of a large eastern utility company and therefore incorporates the experience and resourcefulness of engineers who have learned by "the hard way" that there is no "magic" in locating cable faults.

This cable fault locator is definitely *not* another *magic box!* We shall gladly refer you to users of this equipment, whose experience should be helpful if you have cable fault locating problems.

Please write for Bulletin 65-EE giving full particulars.

JAMES G. BIDDLE CO.
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HIGHLIGHTS........

Institute Opinion Poll. The results of the recent 1949 poll of AIEE membership opinion shows "that over three-fourths of those voting favor carrying on present basic Institute policies as a technical society." To make doubly certain that this is the correct feeling of the membership, a postal card is included on page 193 which the Board of Directors asks you to mark, detach, and mail in before April 15 (*pages 191–4*).

Winter General Meeting. Boasting a record technical program and an attendance of more than 3,200 members and guests, the AIEE Winter General Meeting for 1950 was held at the Hotel Statler in New York (*pages 268–9*). Brief reports of a number of the meeting's technical sessions are included in this issue (*pages 271–7*), as are short authors' digests of most of the conference papers presented (*pages 250–64*).

Social Impact of Television. "Like other great creations of science, television holds the potential of both good and evil, depending upon the uses to which it is put." In this article, the author calls upon the engineer and the scientist to project their interest beyond the technical aspects of their developments and to assume some responsibility for the use made of them (*pages 195–6*).

Electrical Application Problems. The third in a series of articles concerning "Problems and Thesis Subjects From Industry" for electrical engineering education discusses typical electrical application problems which are suitable for this purpose (*pages 241–7*).

Edison and Hoover Medalists. At a general session during the 1950 Winter Meeting, Dr. Karl B. McEachron of the General Electric Company was presented with the Edison Medal for 1949 in recognition of his achievements in the field of lightning and other high-voltage phenomena. The history of the medal and the presentation and acceptance addresses presented at that time are included in this issue (*pages 200–05*). At the same session, the Hoover Medal for 1949 was presented posthumously to Dr. Frank B. Jewett; the medal was awarded for "distinguished public service" prior to his death in November 1949. In his address, Gano Dunn cites the career of Dr. Jewett as "Leader, Statesman, and Nobleman of Science" (*pages 214–15*).

AIEE Special Publications. A complete list of AIEE special publications now available, together with a convenient order coupon, will be found in the advertising section. These publications cover reprints of related articles from *Electrical Engineering*, bibliographies, and compilations of papers and discussions presented at special AIEE technical conferences (*page 30A*).

Testing Turbine Generators. A method for testing governors of steam turbine generators which can be applied simply and without special attachments to the turbine is needed. To meet this need, equipment has been designed which utilizes a sensitive frequency bridge and watt-converter (*pages 225–9*).

Protection of Short Transmission Lines. The first of three companion papers prepared by a working group of the AIEE Relay Committee is presented in this month's magazine. Various protective schemes used on short lines of the metropolitan area of a typical system are discussed in respect to safety, speed, and economics. Pilot-wire protection and carrier-current protection are covered, and the backup protection needed with each is described (*pages 196–9*).

Protection of Lead-Sheath Cable. In order to gather information which would serve as a guide to users and aid manufacturers and those working on specifications, the Insulated Conductors Committee has circulated questionnaires dealing with the use of protective jackets to those who make and use power cable. Recipients were queried on extent of applications, type of construction, service data, and effect on cable rating of the protecting sheath (*pages 223–5*).

Electric Currents in Nerve Tissues. Electric phenomena in living cells has been studied for years. A contrast between the electrical system of an animal body and a conventional electrical system has been made. From this study engineers may gain new insight into the nature of electricity (*pages 231–4*).

Germanium Diodes. One of the fastest-growing markets for germanium diodes is television receivers. The minute germanium diode, one-half inch long and one-fourth inch in diameter, eliminates many of the drawbacks of conventional vacuum-tube diodes. In addition to its tiny size and weight, longer life can be expected from them than from the vacuum-tube ultrahigh-frequency converters, and by using them feedback can be controlled more easily. The germanium diodes are being used as television detectors, television restorers, ratio detectors in frequency-modulated receivers, limiters, and as mixers instead of silicon crystals (*pages 217–20*).

Direct Measurement of Bandwidth. In considering band-pass devices, it is often desirable to know the frequencies passed by a network quicker and easier than can be done by the traditional methods of mathematical or graphical integration. To do this the noise power output of the unknown network is compared to that of a standard network. The description of the equipment and techniques used in this direct method of measurement of bandwidth is presented in this issue, and schematic diagrams are given (*pages 207–12*).

Electronic Telegraph Regenerative Repeater. For use where signal distortion is excessive, the all-electronic repeater has been designed to enable the operator to change codes and speeds quickly and easily and to do routine maintenance in a minimum amount of time. It will tolerate transition of input signals up to 45 per cent because the width of its sampling impulse is less than one per cent of the width of a signal element, and the sampling impulses are timed to be in the very center of an undistorted incoming signal element (*pages 237–40*).

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AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Dec '48, p 35A	Midwest General Southern District
Apr '49, p 25A	Winter General (1949)
Jul '49, p 47A	South West District Summer General
Nov '49, p 51A	Pacific General Fall General
Feb '50, p 46A	Winter General (1950)

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March 1950, Vol. 69, No. 3. Number of copies of this issue 56,400

Let's Reach a Clear Verdict on To Be or Not to Be

JAMES F. FAIRMAN
PRESIDENT AIEE

President Fairman reports on the results of a poll of Institute opinion. The Board of Directors recognizes the purposes of the Institute as being primarily technical, the desire of the membership to be part of an over-all engineering organization, and the necessity for interim handling of nontechnical matters. Membership approval is sought.

TABULATION of the recent opinion poll of AIEE membership discloses that over three-fourths of those voting favor carrying on present basic Institute policies as a technical society. The vote was 7,000 in favor of proposal 1 to adhere to the technical field, versus 2,000 in favor of proposal 2 to expand in the nontechnical field with substantially increased dues.

The poll as it progressed was a continuing education to the poll-takers and to the membership. The presentation to Section officers and delegates at Swampscott, the articles in *Electrical Engineering*,* the question and discussion periods which I had the pleasure of conducting at Section meetings in a score of cities, the hundreds of thought-provoking conversations and letters, all provided an almost infinite variation of shades of opinion which however seemed in some way eventually to merge into one harmonious pattern. Skimming the report of the Board of Directors' special committee shows the poll-taking to have been an enjoyable adventure in statistics.

Returns were remarkably high. While less than five per cent returned the form printed in *Electrical Engineering*, at least one-third returned individual cards mailed to them, considerably more than the 20 per cent which is generally a good response in such a survey. In individual Sections, percentage return on mailed-out cards varied from about 25 per cent in locations like Chicago and Boston to 95 per cent in Arrowhead. In general, the returns were lighter in densely populated metropolitan areas.

Criticism of the form of the propositions was spotty but highly articulate. Chief criticism of them was directed against the phrase, "with substantially increased dues," in the second proposal. A few individual critics thought that omission of the phrase would have reversed the vote; Connecticut, 88–12, thought its vote depended mostly on the money angle; Madison, 83–17, felt that a dues increase would lose members. Others thought the effect slight. Pittsburgh, for instance, with an 85–15 vote, estimated that its report would have shown 70–30 without the dues phrase. Denver, 76–24, and Canton, 87–13, thought the poll a fair one. Boston, 86–14, thought the propositions poorly worded. Regardless of the exact wording of the propositions, it must be remembered that whether expansion would be supported generously was one of the things the Directors wanted to know; the Directors of course were sounding opinion, not asking for decisions.

Executive committees of many Sections quite often favored the second proposal and found that their rank and file supported the first; New York's large administrative group voted 50–50, its Section 82–18. Sharon, 78–22, thought its people voted on feelings, not facts. Milwaukee's meeting vote was 68–32 with the mailed returns reversing to 21–79; Philadelphia, on the other hand, had an opposite experience with the meeting vote 47–53 and the mail vote 85–15. Michigan, 83–17, made reading the *Electrical Engineering* articles a prerequisite for voting. Some Sections engaged in voting on questions in addition to the two listed. The Los Angeles Section, for instance, breaking down the nontechnical activities, voted to support activities on legislation and registration while at the same time voting 66–34 to oppose general AIEE participation in nontechnical activities. The vote favored national participation in activities concerning legislation affecting the profession by 67 to 33, favored Section participation by 74 to 26, but opposed participation in industrial controversy by 70 to 30, in percentages of 500 votes.

Seattle's breakdown into Fellows, Members, Associates, and Students showed approximately even distribution in all classes, 80–20. However, there was a difference in voting between those who had a license and those who did not. Those in favor of adhering to the technical field were evenly split between registered and nonregistered

James F. Fairman is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y.

* See previous articles in *Electrical Engineering:* June 1949, page 536; September 1949, page 749; October 1949, pages 829 and 890; November 1949, page 825.

engineers; only one-third as many registered as nonregistered favored expansion.

Indicated also was a variation in the vote due to geographical location. The Mexico Section and all the Canadian Sections found almost no supporters of expansion. Not a single one of the returns received from overseas favored expansion; overseas members took the trouble to write letters protesting any excursion into the nontechnical field. Such a stand of course is reasonably expectable from the beyond-the-border membership. Since 3,000 members or ten per cent of the total falls in this category, any expansion policy would start with some opposition.

There was also sectional variation within continental United States. East Tennessee, 7–93, North Carolina, 33–67, South Carolina, 39–61, and Georgia, 47–53, constituted the only group of contiguous areas favoring expansion. Adjoining states of Alabama and Virginia voted overwhelmingly the other way, 92–8 and 89–11. Milwaukee, 46–54, and Shreveport, La., 19–81, were expansion islands.

In informal discussions the statement was often made that the younger person would favor expansion. This is not borne out in those Sections where the Student membership was polled, the Student ratio being roughly the same as the active member ratios. (Toledo, 73–27 total and 76–24 Student; New Mexico-West Texas, 86–14 and 80–20).

From Past Section-Chairman Richard Slauer of Lynn, Mass., comes one typical comment:

The diversity of membership in the Institute has only one common bond—technical development of electrical engineering. Therefore this should be aided in any practical manner. There is a place for nontechnical activities (social legislation, economic status, community participation, professional standing, and so forth). But there is no place for such activities as an inherent part of *electrical* engineering. Why should mechanical, civil, and so on, pursue separate and therefore inevitably unco-ordinated courses? Whether nontechnical activities should be grouped into one organization (for example, all engineers, all professional men, all college graduates) or into several, or not grouped except as civic or citizen activities is a very broad question. But failure to get a quick answer to this question should not be used as authority for the Institute to expand into a field where its organization, its background, and its membership do not particularly fit.

And from Associate-Member Donald Wylie of Portland, Oreg., comes an opposite one:

At the present time, most young engineers, including myself, are compressed into the rapidly constricting wage and general social structure that exists between management and the higher brackets of organized labor. The position is at times uncomfortable but as yet is tolerable. Men such as myself, and I feel that I speak for the majority of the membership, need an Institute that will take a deeper view of the social implications and problems of the electrical engineering profession and more actively work to support its professional and social standards. Without being heroic in any way ~~I~~ think I may state that if the Institute fails to provide its membership with representation in every phase of engineering relationships it will most surely be displaced by some new organization that more truly serves the desires of its members. The challenge, now, as always, is to enter freely and fully into the struggle for the advancement of the engineer on all fronts. To reject this challenge is to become another inert milestone on the road of social progress.

Many comments were to the effect that National Society of Professional Engineers might well take over in the nontechnical field; Schenectady, which voted 91–9, Tulsa 50–50, Utah 90–10, and so on. Others were that technical councils should carry on this work, but by far the greatest number of comments were along the line that unification of the profession was an absolute necessity. San Francisco, 80–20, turned its vote in as 50 per cent Plan *D*, 30 per cent technical only under any condition, and 20 per cent for expansion. Richland, Wash., 67–33, on a separate portion of the form showed 90–10 support for an over-all engineering association. Many Sections took the trouble to point out that unification was the considered policy of the Institute.

With the poll of opinion as background, the Board of Directors at its February meeting agreed that a great majority of Institute members considers the Institute as primarily a scientific and educational association. On the other hand it recognizes that thousands of members feel the need for more action in the nontechnical field. The Board of Directors consequently plans:

1. To work continually for the unification of the profession.
2. To recognize the fact that the Institute finds its chief reason for existence in the technical field.
3. To handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis until through unification they can be handled on a general professional basis.

Under item 1 the Directors will continue and, if possible, strengthen their effort to speed up Engineers' Joint Council exploration and consummation of unification. For the many members who are much concerned about the problem of what to do in the interim, it suggests and endorses individual participation in National Society of Professional Engineers, Section participation in local councils, and individual, local, and national preaching of the gospel of unification. Under item 2 the present concentration on technical activities will continue. Included in technical activities are matters of membership, prize awards, education, publication, and co-operation with other societies on technical questions. These in turn require the maintenance of an active program of public relations, both nationally and in the Section areas. Registration will be included as a sort of capstone of the educational process. While a good deal of educational activity might ultimately be handled best by the suggested over-all organization, nevertheless Engineers Council for Professional Development work must continue in its present fashion in the interim period. Under item 3 it should be recognized that the restricted emergency actions of the Board of Directors in the nontechnical field will be much less effective than some would desire. This in itself, however, will tend to accelerate the final completion of some satisfactory form of over-all organization.

The Board of Directors feels reasonably certain that it is correctly interpreting the feeling of the membership of the Institute. It wants to be doubly sure. The postal card on the opposite page gives each of us a chance for expression of opinion. **Won't you mark it, detach it, and mail it in now, before you forget it? The deadline is April 15.** Thank you if you will.

Comments Received

Excerpts From Report of Special Committee

The special committee received 325 notes, letters, or articles commenting on the opinion poll. They ranged all the way from short notes written on the forms, some of which were obviously facetious, to long and thoughtful articles which might be printed as pamphlets.

Most comments were in support of adhering to the technical field, the proposal which won on most of the forms. Typical ones are: "This is the best technical engineering organization in the world so let us keep it that way." "I have been a member since 1893 and we have always pursued this policy." "Let's keep our noses clean." From beyond United States borders came many like this one from London, England: "If, therefore, the vote of your home membership should be in favor of an expansion of the activities of the Institute with the inevitable increase in the yearly subscription, it would be appreciated if you would remember those of us who are concerned with your present technical field only, and upon whom the burden of increased dues would fall impossibly heavy."

An almost unanimous opinion appeared in the very general and wide support of Plan *D*, or the formation of an over-all engineering society. Perhaps the most typical is a question as considered in San Francisco polling, "I favor adhering to the technical field but urge that the strongest possible action be taken toward the implementation of Plan *D*." Similarly, Richland added ". . . but lending its prestige, talent, and support to the formation of an over-all engineering association whose functions shall be the furthering of nontechnical objectives of all engineers."

Third in number of comments were some 42 suggesting that the National Society of Professional Engineers or a similar body represent the engineer in nontechnical matters. Tulsa, after voting 50–50 on the form as it appeared in *Electrical Engineering*, gave unanimous support to the following: "I favor adhering to the technical field, but believe that we should authorize some group, such as the Oklahoma Society of Professional Engineers, to represent us in the nontechnical field; and I favor an increase in dues to sponsor this work."

The next largest number of comments criticized the form itself. Many individuals and some Sections protested the phrase "substantially increased dues" on the grounds that it biased the voting. "Vagueness" was another criticism. "Too specific," "too much like a blank check," were others. Kansas City said, "Our Section should be listed as unanimously opposed to proposal number 1 and also unanimously opposed to proposal number 2. In other words, we are very definitely opposed to both proposals." The Florida Section took no vote on the form as it appeared in *Electrical Engineering* but unanimously approved the following: "I favor continuing in the reasonable activity in the nontechnical field without increased dues." Many individuals wanted expansion without increased dues. The following rather cynical note might indicate why such a proposal would be popular: "Let's expand without any increase in dues. We all believe in Santa Claus!"

There were fewer comments by those favoring expansion into the nontechnical field with increased dues. Several favored a gradual increase in expansion; two said the society must take action to raise the pay of engineers to a proper level; two felt that unionism would force engineering societies to become more active in nontechnical affairs; two said action must be taken on engineering unionism.

The problem of a combined labor–management group, which makes up the society, working together to achieve advances in the nontechnical field was brought forth by several letters. One statement received was this extreme, "No progress will ever be made in that direction (improvement in rates of compensation) so long as top officialdom of the Institute is made up of New York consulting engineers and men taken exclusively from the management bracket."

Many and varying were the minor comments: "Save money by cutting out engraved certificates." "Expand by using the money which could be made out of *Electrical Engineering*." "Registration is one of California's greatest rackets." And many others.

Not all comments were critical. Typical of the nicer ones are: "Have great confidence in the Board of Directors." "Appreciate greatly the opportunity to express ourselves on matters of national policy." ". . . the democratic processes of the Institute."

Everyone of the hundreds of comments received was in some way worth while.

PLEASE

CHECK,

DETACH,

and

MAIL

Poll of Institute Opinion

Three proposals of policy:

1. The Board of Directors will work continually for the unification of the profession.

☐ I approve ☐ I disapprove

2. The Board of Directors recognizes the fact that the Institute finds its chief reason for existence in the technical field.

☐ I approve ☐ I disapprove

3. The Board of Directors will handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis until through unification they can be handled on a general professional basis.

☐ I approve ☐ I disapprove

Signature . . . .

. . . . Section

1949 Membership Opinion Poll on Institute Policy

Section	No. Members	Per Cent Voting	No. Favor Prop. 1	No. Favor Prop. 2	Per Cent Favor Prop. 1-2
Boston	833	23	157	26	86-14
Connecticut	490	5	23	3	88-12
Ithaca	180	58	90	12	88-12
Lynn	266	55	127	18	88-12
Niagara Frontier	266	8	21	1	95- 5
Pittsfield	283	53	112	37	75-25
Providence	132	10	13	0	100- 0
Rochester	214	5	10	0	100- 0
Schenectady	928	23	183	18	91- 9
Springfield	88	8	6	1	85-15
Syracuse	237	67	149	11	95- 5
Worcester	88	55	43	5	90-10
District 1 Totals	4,005	38	934	132	88-12
Akron	118	55	59	6	90-10
Canton	79	49	34	5	87-13
Cincinnati	236	34	67	14	83-17
Cleveland	708	7	40	12	77-23
Columbus	137	60	63	19	77-23
Dayton	341	41	114	18	86-14
Erie	130	57	40	34	54-46
Lehigh Valley	324	15	38	11	78-22
Mansfield	74	17	12	0	100-0
Maryland	626	46	208	81	72-28
Philadelphia	1,344	13	100	70	61-39
Pittsburgh	1,050	42	378	67	85-15
Sharon	178	43	60	17	78-22
Toledo	117	57	49	18	73-27
Washington, D. C.	832	1	6	2	67-33
West Virginia	120	46	34	21	62-38
District 2 Totals	6,414	26	1,302	395	77-23
New York, District 3	4,894	32	1,262	276	82-18
Alabama	199	31	56	5	92- 8
East Tennessee	415	7	2	25	7-93
Florida	137	See Comment			
Georgia	220	65	67	75	47-53
Louisville	115	32	24	12	67-33
Memphis	124	59	62	11	85-15
Miami	97	53	30	21	59-41
New Orleans	246	32	56	23	71-29
North Carolina	229	27	21	42	33-67
Shreveport	74	70	10	42	19-81
South Carolina	122	65	31	48	39-61
Virginia	168	52	78	10	89-11
West Virginia	86	35	24	6	80-20
District 4 Totals	2,232	35	461	320	59-41
Arrowhead	43	95	28	13	68-32
Central Indiana	232	24	51	4	93- 7
Chicago	1,587	26	281	132	68-32
Fort Wayne	125	46	43	14	75-25
Illinois Valley	151	45	62	6	91- 9
Iowa	187	40	62	12	84-16
Madison	75	47	29	6	83-17
Michigan	805	31	208	44	83-17
Milwaukee	688	9	29	34	46-54
Minnesota	279	31	51	36	59-41
Rock River Valley	84	38	28	4	88-12
South Bend	102	53	33	21	61-39
Urbana	99	47	42	5	89-11
District 5 Totals	4,457	29	947	331	74-26
Denver	367	7	19	6	76-24
Nebraska	108	34	27	10	73-27
District 6 Totals	475	15	46	16	74-26
Arkansas	79	66	52	2	96- 4
Beaumont	81	37	30	0	100- 0
Houston	271	49	96	36	73-27
Kansas City	272	See Comment			
Mexico	216	46	100	0	100- 0
New Mexico-West Texas	148	63	80	13	86-14
North Texas	385	73	169	54	77-23
Oklahoma City	180	52	80	14	85-15
Panhandle Plains	131	75	84	14	86-14
St. Louis	521	35	173	9	95- 5
South Texas	163	50	67	15	82-18
Tulsa	139	50	35	35	50-50
Wichita	82	40	32	1	97- 3
District 7 Totals	2,668	46	998	193	84-16
Arizona	131	34	36	9	80-20
Los Angeles	1,289	39	332	172	66-34
San Diego	157	27	37	6	86-14
San Francisco	1,259	7	55	32	61-39
District 8 Totals	2,836	24	460	219	68-32
Montana	90	30	25	2	93- 7
Portland	438	55	170	71	71-29
Richland	94	64	40	20	67-33
Seattle	422	56	187	47	80-20
Spokane	128	51	45	20	69-31
Utah	115	61	63	7	90-10
District 9 Totals	1,287	54	530	167	76-24
Montreal	296	34	100	0	100- 0
Niagara International	101	56	51	5	91- 9
Ottawa	56	71	40	0	100- 0
Toronto	557	9	50	0	100- 0
Vancouver	182	38	64	6	93- 7
District 10 Totals	1,192	26	305	11	97- 3
Section Total	30,460	31	7,245	2,063	78-22

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The Social Impact of Television Upon the Scientist and the Engineer

E. FINLEY CARTER
MEMBER AIEE

Television is potentially good for society; if it is not handled properly it can be a source of evil. To help assure the greatest social benefits of their developments, the author urges the scientist and the engineer not to confine their attentions to the technical aspects of their work, but to assume an active responsibility for the manner in which these new tools are used.

THE SUBJECT, "The Social Impact of Television," is one which both provokes our thoughts and stirs our spirits. Our emotions are mixed—there is pride of accomplishment as well as a measure of awe and a bit of fear. Like other great creations of science, television holds the potential of both good and evil, depending upon the uses to which it is put.

One needs only to observe the growing membership and prestige of the various professional and scientific associations to appreciate the social and economic impact of scientific findings as applied to articles of commerce. As technical developments become more numerous and complex, the number of trained men required to design, produce, sell, and service the resulting products also increases. Television promises to accelerate this growth.

It is evident that many scientists and technically trained people will become direct beneficiaries of television simply because of the demand such a new industry places upon technical knowledge and skill. Many also will benefit by being on the receiving end of programs devoted to sports, current news, drama, or specific educational topics. This, however, is in a sense passive participation, the social impact of which will depend almost entirely upon the extent to which translation into action takes place.

THE SCIENTIST AND SOCIETY

It is not unfair to state that, until recently, the scientist and engineer have been too prone to concentrate their active effort upon discovery of new physical principles and the creation of new devices while ignoring completely their impact upon society. We have been apt to beget our brainchildren with reckless abandon and then cast them upon a society not fully able to cope with them, much less than to direct their use into worth-while channels. We would certainly be considered disreputable parents should we follow the same practice in regard to our biological progeny.

Since the advent of the atomic bomb, there has been increasing evidence of an awakened sense of social responsibility on the part of the scientist. It may be that some of the underlying social interest has always been present, but the evidence has been made more apparent by this significant development. Much has been said about the bomb and its effect upon society. It may be that its social impact will not be as profound as will be that of television. Therefore, while accepting the passive and automatic benefits that we will derive from this new industry and from video programs, let us consider the responsibility we will assume in the active direction of this new tool to insure realization of the social good latent within it.

The scientist, like the cleric, has too often been typified by movies, as well as by some businessmen and industrialists, as a long-haired dreamer. This is partly a satisfying defense mechanism; also it often salves peoples' egos to make oddities of those who are versed in the things that they themselves do not understand. However, the label has been earned by those scientists who have allowed the cold logic of precise mathematical expressions or physical formulas to crowd out an understanding of the human equations associated with the society in which they live. Paradoxical as it may seem, television on the one hand can encourage a cool aloofness to human society by causing a person to withdraw into the confines of his own home, or it can make him a veritable citizen of the world by arousing his finer emotions and broadening his field of interest—and the latter influence can prevail. Furthermore, we can study through this medium the needs and interests of society at large and so develop a keener sense of our own social responsibility. This will not happen, however, without effort on the part of men and women with sufficient vision to see beyond the immediate dollar profits to be gained.

HOW THE SCIENTIST CAN CONTRIBUTE

Nothing can destroy our present social system more quickly than the exploitation of men and products for monetary gain alone. Where the product has the social significance of television, the moral responsibility is great. It behooves those who prize the free enterprise system to take stock of where we are going and to apply both knowledge and vision in directing the use of new developments to make a better society and not just a wealthier one.

Several suggestions can be made that may aid in accomplishing this end. First, the role of the scientist and engineer must not be that of just a critic. We, as members of that group, cannot wash our hands of the responsibility for producing instruments potentially evil just because we intended them to be used for good. We must analyze the

Essentially full text of a paper presented at a joint session of the AIEE New York Section and the American Association for the Advancement of Science held during the 116th Annual Meeting of the AAAS in New York, N. Y., December 26–31, 1949.

E. Finley Carter is Vice-President, Sylvania Electric Products, Inc., New York, N. Y.

situation as logically as we would any other complex problem and then use our influence in obtaining a proper solution. This will require more active participation in community, professional, and business activities than that to which many of us have been accustomed. By being good citizens and broadening our fields of interest we can more constructively participate in influencing the manner in which great developments like television are used.

Next, the scientist and the engineer, because of the increasing technical complexities of our civilization, must be prepared to accept more active leadership in business and in political fields. That this trend has already set in is evident. In a census taken by the Massachusetts Institute of Technology it was found that 601 of its graduates hold positions as presidents of important corporations. This may be taken as an example of a definite trend so far as industry is concerned. Television will increase the need and opportunity for such service through business leadership.

In regard to the role of associations such as the American Association for the Advancement of Science and the AIEE, there are, perhaps, no groups in a better position to exert the kind of influence needed. Such groups can encourage sessions devoted to considering "The Social Impact of Television." They can season their technical publications with occasional discussions of the social implications of new developments. They might even set up committees to study and report on the relations of scientific developments to the advancement of society. Through the guidance of such committees, individual members in their various professions might exert influence toward assuring programs of an intellectual and moral level which will not have destructive influences upon their audience. Without doubt, it will take effort to guarantee that the social impacts of television will be constructive, but it can be done.

Man can and must be master rather than slave of his creations—but the balance can be easily tipped in the direction of making man the slave. The secret lies in learning to know people and in getting them to understand each other and to work together. That factor alone can make a harmonious and progressive society. Television can be both an incentive and a means for accomplishing this end. Is it not time to combine some of the cold analytical logic used so effectively in solving our physical problems with warm human emotions to the recognition and application of the basic principles of human relations? Surely you will agree that it is.

Protection of Short Transmission Lines

W. E. MARTER
ASSOCIATE AIEE

First of a series of three articles concerning relay protection of transmission lines, this article describes the relays used for protection of short lines of the metropolitan area of a system. Discussions are presented on pilot-wire and carrier-current protection with regard to speed, safety, economics, and added back-up protection necessary.

As a result of a study made by a working group of the AIEE, three companion articles have been prepared on transmission line protection. The articles are based on a study of a typical transmission system which is shown in Figure 1. A reactance diagram of the system is shown in Figure 2. The study was divided into three parts covering the short lines interconnecting the metropolitan area of the system, the medium-length lines tying to nearby sources or interconnecting with other systems, and the long lines connecting to remote sources or systems.

This article deals with protection which might be applied to the short lines connecting the generation and switching stations in the metropolitan area. These are the lines between station busses *B*, *C*, *E*, *F*, and *G* on Figure 1. These lines consist of three 138-kv lines of 9, 13, and 15 miles and six 69-kv circuits consisting of three parallel circuits of seven miles each, two parallel circuits of nine miles each, and one circuit of 23 miles.

These circuits form a metropolitan network with a load of 395 megawatts and local generation of 140 megawatts. The remainder of the load in this area must be supplied from other sources which are comparatively remote from the load. The distribution of generation on the system and the fact that various sources might be shut down during light load periods indicated that difficulty would be encountered if an attempt was made to relay

Full text of paper **50-69**, "Transmission Line Protection of Short Lines of the Metropolitan Area of a Typical System," recommended by the AIEE Relay Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

W. E. Marter is with the Duquesne Light Company, Pittsburgh, Pa.

the short lines of the system on a time selection basis. Since the metropolitan network of the system forms the tie between various remote sources, it was felt that protection should be installed which would not be affected by through-fault or swing currents but would clear the faults as rapidly as possible. The rapid-clearing requirement suggests the use of either carrier-current protection or, with the short lines involved, pilot-wire protection.

PILOT-WIRE VERSUS CARRIER-CURRENT PROTECTION

A choice between pilot-wire protection and carrier-current protection from the standpoint of speed of operation is difficult to make, as the operating time of either type is approximately one cycle.

With regard to the reliability of pilot-wire schemes, a few quotations from a report prepared by an AIEE Relay Subcommittee in 1942 on the subject "Pilot-Wire Circuits for Protective Relaying—Experience and Practice"[1] indicates the excellent reliability of pilot-wire circuits. The introduction states:

"This report is based on replies of 32 companies covering 436 circuits used for protective relaying. The information thus obtained covers 1,351 route miles of pilot-wire circuits and a period of 5,570 circuit years."

The summary, item 5, says, "The service continuity reported based on 5,570 circuit years indicates an average out-of-service time of less than 0.0335 per cent. It appears that the leased circuits have more frequent interruptions, but of shorter duration than the privately-owned circuits."

An analysis of the figures in this report indicates 1.32 interruptions per circuit year with an average of 2.58 hours each for leased circuits, while the privately owned circuits have 0.575 outage per year with an outage time of 5.08 hours per outage. The out-of-service time includes "planned interruptions" or "circuit rearrangements."

A similar report on performance of carrier channels would be of interest for comparative purposes, but no such summary is available as far as is known; however, it is expected that comparable information will be available.

The cost of pilot-wire protection cannot be fixed easily since the cost per terminal varies with the cost of the pilot-wire channel, assuming that one-half the cost of the pilot wire is charged to each terminal. If the cost of the terminal equipment for pilot wire is considered, the difference between that cost and the cost of a carrier-current terminal determines the maximum amount which can be spent for a pilot-wire channel.

The installed cost of a single-terminal carrier-current protection varies on the average from $6,500 to $7,500. This cost is broken down into approximately $4,500 for equipment and $2,000 to $3,000 installation costs. These are conservative figures, and in some cases, estimates as high as $15,000 per terminal have been made.

The installed cost of a single-terminal equipment for pilot-wire protection is approximately $2,500 to $3,500, of which $1,200 is the approximate cost of equipment, including continuous supervision and neutralizing transformers. This allows an over-all cost of pilot-wire channel of approximately $8,000 at which figure the two schemes of protection are economically equal. If a pilot-wire channel costs more than $8,000, it is more economical to use carrier protection, and if it costs less than $8,000, it is more economical to use pilot-wire protection.

With either carrier-current protection or pilot-wire protection it is sometimes necessary to remove the carrier transmitter or pilot-wire circuit from service for maintenance. Since this removal of equipment from service generally makes the relay protection inoperative, it is necessary to provide additional relay protection on the line if it is desired to keep the line in service. This additional protection provides primary protection for the line when the carrier or pilot-wire equipment is out of service and frequently can be made to serve as back-up protection when pilot wire or carrier is in service.

PILOT-WIRE CIRCUITS

Pilot-wire circuits may be either leased from the local telephone company or owned by the power company. In

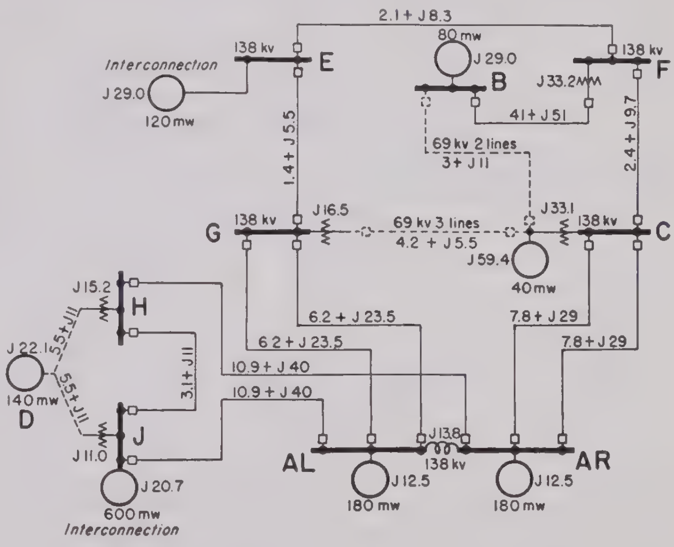

Figure 1. Typical transmission system

some cases power companies own telephone or other circuits which can be used for pilot wire, and in other cases it is necessary to build pilot-wire circuits.

LEASED CIRCUITS

Conductors leased from the telephone companies average $40 to $50 per year per loop mile of pilot-wire circuit, excluding taxes. If the $50 rental is capitalized at 12 per cent, the investment represented is $417 which would permit leasing a pilot-wire circuit 8,000/417 = 19 miles long. If an 18 per cent capitalization figure is used, the length of pilot-wire circuit which would be justified economically is increased by 50 per cent, so that the economically justified length of pilot wire on a lease basis depends on the percentage on which the rental charge is capitalized.

PRIVATELY-OWNED CIRCUITS

If pilot-wire channels are to be built and the relay manufacturers' preference for lead-covered cable circuit is followed, the length of pilot-wire circuit is quite limited

because of cost. There are in successful use several pilot-wire channels which are not in cable which should be considered. Pilot-wire channels consisting of insulated copperweld wire closely spaced and mounted on distribution poles have been in operation for some time. In addition to low cost, this type of channel has two advantages over a telephone cable type of circuit. The resistance and capacitance of such a circuit are low, and the insulation level is high.

Conductors used for such an installation are mounted on a single-grooved spool and have a spacing of less than two inches. The conductors are number 10 copperweld-copper, 40 per cent conductivity, with 3/64-inch performance-grade rubber insulation, American Society for Testing Materials designation *D*-27 containing 30 to 33 per cent crude rubber, and two asphalted braids slicked. Breakdown voltage of such insulation is 300 volts per mil, or slightly under 15,000 volts. Such a conductor will withstand a direct contact with a 4-kv or 6.9-kv distribution circuit without damage or any effect on the pilot-wire protection. Loop resistance is 13.5 ohms per mile of circuit. The cost of such a circuit is 4.5 cents per foot per conductor on existing poles or slightly over $475 per loop mile. This figure is somewhat above the $50 rental figure capitalized at 12 per cent.

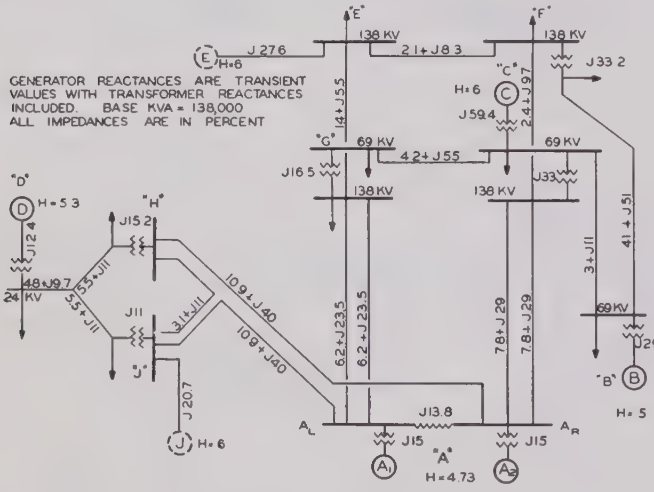

Figure 2. Positive sequence impedance diagram of a typical transmission system

The use of "spiral-four" cable for pilot-wire circuits has been quite successful. This cable has four rubber-covered conductors enclosed in a foil shield and woven steel wires all enclosed in a rubber jacket. Since the war, this material has appeared on the market as war surplus material at a very reasonable cost.

Another expedient for reducing the cost of pilot-wire installations would be to use a phantom simplex circuit where several pilot wires follow the same route. No information on the use of such a scheme has appeared in any articles which have come to the attention of this author, but it seems that such a connection might have sufficient merit to be investigated, since circuits of this type have been used by telephone companies for years.

The major objection to such a scheme is that an outage on one pilot-wire pair will remove the pilot-wire protection from two lines, but usually pilot-wire outages are rare, and if adequate back-up protection is provided, the double pilot-wire protection outage is not too objectionable. The simplex scheme will reduce the pilot-wire resistance, but where the simplex circuit is in, cable may raise the capacity of the pair to an objectionable value.

BACK-UP PROTECTION

With pilot-wire protection or any other type of protection which will not recognize a fault in the adjacent section, it is necessary to install some additional protection on the system, since a failure of the pilot-wire type of protection to clear a fault in its protected zone has no effect on the protection of this type on the remainder of the system, and therefore, a fault could remain uncleared. An uncleared fault on a system can result in serious and expensive damage to conductors and windings of equipment feeding the fault and may cause additional failures which would result in a complete system shutdown. Several cases of this type have occurred in various parts of the United States, and there is a definite justification for expenditures for this type of additional protection on an insurance basis alone.

The additional protection is usually referred to as back-up protection and may consist of a simple overcurrent protection with or without directional features set high in time and current, or a more complicated scheme which provides a protection having operating characteristics similar to the primary protective scheme.

The two primary causes of a failure of a fault to be cleared are the mechanical failure of the circuit breaker to operate after having received the proper tripping impulse or the failure of the protective relay system to deliver the tripping impulse.

Mechanical failure of circuit breakers to trip may be caused by a failure of any one of the many mechanical parts of a circuit breaker, such as bearing failures in any one of the many pin bearings, broken or bent trip plungers, or broken or distorted castings or other parts of the mechanism. Collection of moisture in circuit-breaker mechanism housings may freeze during low temperatures and prevent the operation of the circuit breaker.

Failure of the circuit breaker to receive a trip impulse may be caused by a failure of the instrument transformers feeding the relays or may be in the wiring between the instrument transformers and relays. The failure may be due to open- or short-circuited windings in the coils of the relay or some foreign matter blocking the operation of the relay or to defective relay contacts. Failure may be due to failure of the tripping source or to any of the numerous contacts, coils, or wiring that comprise the trip circuit.

In order to furnish a complete back-up for any or all of these failures, it is necessary to have an independent set of relays operating from separate instrument transformers and having a separate trip source tripping a separate circuit breaker or group of circuit breakers. Back-up protection seldom, if ever, goes to the extent which has been described, but the condition is closely approached.

The application of back-up protection is influenced on any given system by past experience on the system and experiences which have been reported on other systems. Applications are made to cover failures which have had serious results in the past, or from an analysis of the system which shows that serious results could occur from a failure to clear a fault.

On any high-voltage system, the equipment which has the highest failure rate is the transmission line. Therefore, the line circuit breakers have a greater chance of failing to operate properly on a fault than any other circuit breakers on the system. It would seem then that one of the most necessary back-up installations is on the line protection. It might be argued that a bus fault is more serious than a line fault, but from the standpoint of system disturbance and short-circuit current, the results are the same since the determination of whether a fault is a line fault or a bus fault is made depending on which side of a line circuit breaker the fault is located. From this discussion, it should not be concluded that bus back-up, transformer back-up, or generator back-up is unimportant, since oil fires resulting from transformer failures and iron damage due to prolonged faults in generators can have serious effects on a system.

PROTECTION RECOMMENDED FOR THE SHORT LINE

From the comparison of costs of carrier-current protection and pilot-wire protection, it can be seen that with 18 terminals involved and with a cost differential $4,000 per terminal installed the two schemes would be economically equal if the pilot-wire circuit cost was $72,000. Since pilot-wire circuits could be built for the 99 miles of line involved for approximately $47,000, the saving in favor of pilot-wire circuit is $25,000.

An additional advantage of pilot-wire over carrier protection is the simplicity of the pilot-wire circuits and connections.

Pilot-wire protection is chosen, therefore, for the primary protection of these lines and provides instantaneous clearing of both phase and ground faults for the entire line.

The following items should be considered and, where necessary, included in the pilot-wire protection.

1. Rise in station ground potential and induction should be studied to determine whether neutralizing transformers are required.

2. Consideration should be given to the installation of continuous supervision on the pilot-wire circuit for the purpose of cutting out the pilot-wire protection when the pilot-wire circuit becomes defective and for the purpose of automatically switching the back-up protection where simple back-up is used. There also may be some question of the back-up operating unnecessarily under certain system conditions.

3. Use of instantaneous phase and ground overcurrent relays with their trip contacts in series with the pilot-wire relay trip contact chould be considered. These relays have been found to be very successful in preventing unnecessary operation of the pilot-wire relay due to foreign voltage on the pilot-wire circuits from such causes as accidental application of telephone test voltages, contacts with other pairs in the same telephone cable, contacts with power circuits, and induction from circuits at voltages below the voltage of the protected line section.

4. The pilot-wire circuits should be carefully scrutinized, particularly the long circuits to determine that the relay manufacturers' limitations of resistance and capacitance have not been exceeded.

5. Pilot-wire circuits leased from telephone companies may contain loading coils, and the effect of the loading coils on the proper operation of the pilot-wire protection should be considered.

The back-up protection proposed for the lines being discussed is step-distance protection with product-type ground protection. A consideration of directional overcurrent protection indicates that some difficulty might be encountered in obtaining proper time selection, since the location of power sources could vary widely with different generating sources shut down for maintenance purposes or during light load conditions on the systems.

The back-up relays should be connected to auxiliary current transformers connected in the secondaries of the bushing current transformers on the line side of the circuit breaker. These current transformers normally feed bus differential, and the current transformers on the bus side of the line circuit breakers are used for the primary line protection. With this connection, the operation of the bus differential must be checked to see that it has not been adversely affected by the additional burden.

The back-up relays should trip the line circuit breaker and at the same time energize a time-delay relay. The time-delay relay is set with sufficient time delay to allow the line circuit breaker to clear the fault. If the fault is not cleared, the contacts of the time-delay relay should be connected to an auxiliary relay which will clear the bus section to which the defective line is connected. The primary line protection should also operate the same time-delay relay. One time-delay relay per bus section is required for this back-up scheme.

The back-up protection described provides independent relays fed from independent current transformers and provides back-up for a mechanically sticking circuit breaker. It is assumed with this type of back-up that failure of two pieces of equipment will not occur at the same time. As an example, if pilot-wire protection is defective, it is assumed that the current and potential transformers feeding the back-up protection will not be defective at the same time.

In conclusion, it might be pointed out that on short lines requiring protection in the instantaneous classification pilot-wire protection can be justified economically, and it provides both phase and ground protection.

The back-up protection chosen provides phase protection which, while not the equivalent of pilot-wire protection, provides instantaneous tripping for one circuit breaker of the line on all faults and instantaneous tripping of both ends of the line for faults in the middle 75 to 80 per cent of the line. The ground protection will require selective timing, the selection being determined from a ground fault study of the system.

With the back-up timer connected, as indicated, all possible line tripping failures are covered except a failure of the control battery.

REFERENCE

1. Pilot-Wire Circuits for Protective Relaying Experience and Practice, **AIEE Committee on Protective Devices, Relay Subcommittee.** AIEE *Transactions*, volume 62, May 1943, pages 210–14.

Karl B. McEachron—Edison Medalist for 1949

The Edison Medal for 1949, an annual award for meritorious achievement in electrical science which constitutes one of the nation's highest engineering honors, was presented to Dr. Karl Boyer McEachron of the General Electric Company on Wednesday, February 1, during the 1950 AIEE Winter General Meeting in New York, N. Y. Dr. McEachron was awarded the medal "for his contributions to the advancement of electrical science in the field of lightning and other high-voltage phenomena and for the application of this knowledge to the design and protection of electric apparatus and systems."

The Edison Medal

J. B. MacNEILL
FELLOW AIEE

THE EDISON MEDAL is being presented this year for the 39th time since it was originated in 1904.

The Edison Medal Association, a group of associates and friends of Thomas A. Edison, "was organized for the purpose of appropriately recounting and celebrating the achievements of a quarter of a century in the art of electric lighting, with which the name of Thomas Alva Edison is imperishably identified."

It seemed to the association "that the most effective means of accomplishing the object for which it was formed would be the establishment of an Edison Medal, which should, during the centuries to come, serve as an honorable incentive to scientists, engineers and artisans, to maintain by their works the high standard of accomplishment set by the illustrious man whose name and features shall live while human intelligence continues to inhabit the world."

The AIEE was given the responsibility of making the awards and does so through the Edison Medal Committee of 24 members.

The bylaws of the committee require that the award go to a resident of the United States of America or its Dependencies, or of the Dominion of Canada, whenever in the judgment of the committee such a resident is deserving of the award, provided funds are available. The award is for "meritorious achievement" in electrical science or electrical engineering or the electrical arts.

The medal, designed by James Earle Fraser, carries on the obverse the portrait of Thomas A. Edison and, on the reverse, an allegorical conception of the genius of electricity crowned by fame.

With the growth of the electrical industry, as shown by the great increase in membership in the Institute, there have developed many outstanding engineers and inventors who would qualify for this award. Of recent years the number of meritorious nominations has made the task of selection a difficult one, and final choice has been possible only after complete discussion in the committee. This fact only adds to the honor which is conferred on Dr. Karl B. McEachron, who now joins the illustrious company of 38 previous holders of the Edison Medal.

Dr. McEachron has contributed, through his research on high-voltage phenomena, to the successful growth of the fundamental electric system which Mr. Edison initiated. He has carried forward the tradition of invention and development which marked the work both of Edison and of Dr. Elihu Thomson who received the first award in 1909.

Full texts of the presentation and acceptance addresses given at the Edison Medal ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950.

J. B. MacNeill, Chairman of the Edison Medal Committee, is Manager, Switchgear and Control Division, Westinghouse Electric Corporation, East Pittsburgh, Pa.

The Edison Medalist

D. D. EWING
FELLOW AIEE

TWO HUNDRED years ago Benjamin Franklin, by vocation a printer and journalist, and by avocation, a politician, diplomat, philosopher, and scientist, was spending his "avocation time" experimenting with static electricity and the newly invented Leyden jar. He presently came to the conclusion that the discharges from a Leyden jar were similar in general character to those occuring during a thunderstorm. But how to prove this conclusion experimentally? With a little shed in a small field near Philadelphia as a laboratory and with his precious Leyden jar and a kite as experimental equipment, and a thunderstorm as a source of electricity, Franklin in 1752 proved his theory. He thereby demonstrated conclusively that a lightning discharge is neither a display of the power or wrath of deities nor of the arrogance of devils, but rather is a large-scale demonstration of the silk cloth and glass tube experiment. Franklin's experimental work was of necessity of a qualitative nature. However, he blazed a trail that has been assiduously followed and greatly widened and extended by the man who has been awarded the Edison Medal for 1949, the highest honor bestowed by the Institute for meritorious achievements in "electrical science, electrical engineering, or the electrical arts."

THE MEDALIST

Karl Boyer McEachron was born in Hoosick Falls, N. Y., in 1889. He grew up there, and as a boy did the usual

D. D. Ewing is Head, School of Electrical Engineering, Purdue University, Lafayette, Ind.

things a small-town boy of that time did. His father was a jeweler, and so the boy grew up among ticking watches and clocks, possibly thereby acquiring quite naturally a considerable amount of mechanical mindedness. As a youth he built canoes, automatic skate sharpeners, and cameras, and learned to play a horn. While in high school he served for a time as a night operator for one of the Bell Telephone companies. For four years following graduation from high school, he worked for a small telephone company, serving in progression as a helper, lineman, cable splicer, switchboard maintenance man, and troubleshooter.

Living so near the great General Electric Company plant at Schenectady, and hearing so much of the fame of Edison and Steinmetz, it was but natural that he should have been attracted to an engineering career. My own acquaintance with our medalist began shortly after he enrolled in engineering at Ohio Northern University. He came into my office to discuss his program of study, to ask questions—and to be asked questions. I no longer remember the date or many of the details of this conversation, but I do recall that the bushy-haired, earnest-eyed youngster made a very definite impression upon me. In part, this may have been because students from east of the Hudson were rare in small midwestern colleges in those days. Also, Hoosick Falls was the headquarters of a farm implement manufacturer whose name was almost as well known in the rural middlewest as was that of Cyrus McCormick. The fact that the young man knew something of watches and clocks may have had something to do with it too, as I was interested in timepieces as a hobby.

Karl B. McEachron

In college, McEachron was a distinguished student, persistent in the pursuit of facts and in accomplishing tasks. He had an enormous bump of curiosity and was always hunting—and finding— the reasons for things. He took an active part in the affairs of the Institute Student Branch and played in the college band.

Graduating in both electrical and mechanical engineering in 1913, he shortly thereafter entered the employment of the General Electric Company at its Pittsfield, Mass., plant. Because of his ability and his interest in dielectric phenomena, he was soon made foreman of tests in the then newly organized high-voltage laboratory. His work there so interested him that it influenced his life career in a major way.

Feeling the need of a better understanding of the fundamentals of electrical engineering and desiring to acquire greater ability "to think and talk while on his feet," he returned to Ohio Northern University in September 1914 as an instructor. Here an incident occurred which is worth relating as a typical illustration of his resourcefulness and persistence. Because certain experimental results did not seem to agree with theory, Dr. McEachron finally decided that there must be something wrong with the waveform of the alternator used in the experiment. But how to determine this waveform? The ubiquitous cathode-ray oscilloscope of today was unknown. Electromagnetic oscillographs were few and far between and not within the financial means of a small college. McEachron, starting at scratch, built an oscillograph and then found the answer to his query.

In 1918 he joined the staff of Purdue University as a research worker in the Purdue High-Voltage Laboratory and as a part-time teacher. He distinguished himself in both fields. His research work was mostly along the lines of atmospheric nitrogen fixation by the high-voltage discharge method, ozone production, and the photography of dielectric fields. This work was distinctive because of Dr. McEachron's originality and resourcefulness.

He received the Master of Science degree in Electrical Engineering at Purdue University in 1920 and returned to the General Electric Company in 1922 as head of the Development and Research Section of the Lightning Arrester Engineering Division at Pittsfield. In 1933 he became Engineer of the High-Voltage Laboratory, and in 1940 was appointed Designing Engineer. He occupied this position until 1945 when he was made Assistant Works Engineer of Power Transformers. Since September 1949, he has been Manager of Engineering for the Transformer and Allied Products Division of the company.

TECHNICAL ACHIEVEMENTS

Dr. McEachron's outstanding achievements naturally have been in the high-voltage power field. Taking up where Franklin, and later Steinmetz, left off, he, figuratively speaking, "has tracked lightning to its lair" and measured it. He has made many improvements in the way of measuring high-voltage discharges from both high-power sources and impulse generators. He and his associates adapted the high-voltage Dufour oscillograph to the

measurement of microsecond discharges, making the first oscillogram of a short-time impulse discharge in 1924. The use of the oscillograph in itself was not particularly new, but the ability to time the discharge so that it would appear on the screen with the necessary control and all the rest that went with it, was the first long step towards solving the mystery of what lightning is and what to do about it.

Later this equipment was so developed that it could be taken into the field to measure actual transmission line surges caused by lightning. Dr. McEachron thus did what Franklin was unable to do, namely, he obtained quantitative data on lightning discharges. He has been ever alert to learn everything possible about nature's lightning and has acquired a vast amount of data relative to it. His work along this line in connection with the study of strokes to the tower of the Empire State Building is well known because of its popular interest. Not so well known, however, is the fact that for years every thunderstorm, whether during the day or at night, found Dr. McEachron in his lookout tower at Pittsfield with his cameras trained on the skies.

Using the artificial lightning generator, Dr. McEachron has been able to study the lightning stroke under controlled conditions and has solved many of the mysteries surrounding the erratic behavior of such discharges.

Being a very practical sort of an individual, it was only natural that Dr. McEachron should work equally hard on methods for mitigating lightning damage. He invented Thyrite, a material particularly well adapted for use in lightning arresters. Based on this invention, a number of new or improved types of arresters have been developed.

Studies of grounding methods and of the component insulations of high-voltage devices have also come under Dr. McEachron's scrutiny and have been studied from the standpoint of performance under surge conditions.

He has done much also in the way of formulating methods of protecting transmission lines and other structures from lightning damage.

HONORS

In 1931, Dr. McEachron received the Coffin Award of his company for his invention of Thyrite. His achievements were recognized by the Franklin Institute in 1935 when it awarded him the Edward Longstreth medal. In 1938, he received the honorary doctorate degree from Ohio Northern University, and in 1941 a similar degree from Purdue University.

PROFESSIONAL ACTIVITIES

Dr. McEachron's professional activities started in college days with his activity in the local AIEE Student Branch. They have been continuous since then. He became an Associate of the Institute in 1914 and a Fellow in 1937. He has served as Chairman of the Pittsfield Section, as Vice-President of District 1, and as a Director of the Institute.

He has also been an active and valued member of many Institute committees.

Among other activities, he is a member of the Massachusetts Board of Registration of Professional Engineers.

From 1937 to 1945, Dr. McEachron was a member of National Advisory Committee for Aeronautics Subcommittee on Lightning Hazards to Aircraft. During World War II, he served the United States as chairman of the Advisory Committee on Lightning Protection of the Army's Safety and Security Division.

Dr. McEachron's first published papers were in the form of "Bulletins" of the Purdue Engineering Experiment Station. Since then he has published some 60 papers covering his researches and contributions to the engineering arts. These have appeared in the Institute publications, *Journal* of the Franklin Institute, and in other well-known technical journals.

As a speaker, Dr. McEachron has been much in demand by the AIEE Sections. He has an unusual ability to make technical things interesting to laymen and has filled numerous speaking engagements with nonelectrical organizations.

Somewhere along the line, Dr. McEachron developed the Socratic habit of questioning. When he approaches a new problem, or a new aspect of an old one, he has the inquisitiveness of Franklin. He asks himself and his colleagues all sorts of questions bearing on the "why" or "how" and then proceeds to hunt the answers. I judge that this habit has been in no small way an aid in his many successful solutions of difficult problems.

Because I have known Dr. McEachron and of his work for so many years, it is indeed a pleasure to express my admiration of his achievements, my personal esteem for him both as an engineer and as a man, and to greet him as the Edison Medalist for 1949.

Industry Solves the Lightning Protection Problem

KARL B. McEACHRON
FELLOW AIEE

I DEEPLY APPRECIATE the honor which the Institute has conferred on me in awarding me the Edison Medal for 1949. I accept this award on the basis that it is given not only for whatever personal accomplishment I have been able to make in the field of lightning and of lightning protection; but also in recognition of the contribution of the many other persons associated with me both outside and within my own company. Some indication of their contribution will be apparent from a brief résumé of what has happened in this field in the last 27 years.

EARLY PROTECTION METHODS

From the time wires were first put on insulators on poles to carry electricity, either for communication or power, lightning has been a source of interruption to service. In

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Dr. K. B. McEachron observing and photographing a flash of lightning in the General Electric Lightning Observatory at Pittsfield. Mass.

the communication field, through an evolution of various designs, lightning protectors using gaps in some form were developed so that, except for split poles or cross arms, a reasonable degree of satisfactory operation was obtained.

For the power companies with overhead wires, similar developments took place but with much less degree of success. Flashovers on power lines, because of the relatively high voltage between phases or from phases to ground, occurred frequently during lightning storms resulting in interruptions to service. To remedy this situation the so-called static wire came into use, but because of lack of knowledge of the relationship between its resistance to ground and its location relative to the line conductors, its use was not regarded as being at all satisfactory. Not knowing the possible magnitudes of the lightning current, no one knew how to design so as to build a line whose service could be free from interruption due to lightning. In many cases the static wire became a hazard in itself because of the use of too small a wire and improper support.

For the protection of apparatus connected to lines, such as transformers, lightning arresters had been developed by 1922 consisting essentially of a gap, or combination of gaps, together with a valve element to limit the magnitude of power system follow current, so that the arc in the gap would be quickly extinguished. At this time, application of arresters was based on the expectation that the transformer strength was greater than the lightning potential allowed by the arrester. There was considerable skepticism, however, since the only measure of the arrester's performance was based on protecting a gap of known spacing. Early in 1922 a length of lead-sheathed cable, charged up to 100 kv by a temperamental static machine, was the impulse generator in use in the High-Voltage Laboratory at Pittsfield for testing lightning arresters. The wave shape of the applied wave was not known, nor was the volt-time flashover characteristic of gaps known. Likewise, the lightning strength of transformers could not be determined with much accuracy. It is worthy of note that the static machine was replaced by kenetrons and the cable by glass plate capacitors by the end of 1922.

All of this does not mean that efforts were not being made to solve these problems; on the contrary, F. W. Peek Jr., in the Pittsfield High-Voltage Laboratory, had in use an impulse generator giving voltages of the order of one million volts. With this equipment considerable data had been obtained from many tests made on insulation, insulators, bushings, and certain apparatus. However, Peek was not able to accomplish results quickly nor accurately, because of serious limitations in the lightning generator used. The polarity and repetition of wave shape were somewhat uncertain, which was a result of the method of charging used at that time. Furthermore, since the needle gap and sphere gap were the only means available for measuring voltages, the determination of wave shape required hours of tedious testing using a point-by-point method. This method required exact duplication of the wave many times, and the results when finally obtained were viewed with suspicion.

Such was the situation in 1922. Progress was slow, the possibility of solving the lightning problem was not good, the direct stroke was considered by many to be quite out of man's control, and lightning had become the limiting factor in continuity of service on many systems, accounting for as much as 75 per cent of the interruptions to service. Obviously the utility operators were ready to engage in any program which offered an opportunity to improve the situation. In Chicago an extensive investigation was under way of the performance of different makes of lightning arresters protecting approximately 30,000 distribution transformers. The results were inconclusive, chiefly because the proper instrumentation was not available to secure reliable answers.

THE CATHODE-RAY OSCILLOGRAPH

The complexion of the whole problem changed in 1924 with the introduction of the cathode-ray oscillograph, which permitted, for the first time, recording the volt-time, ampere-time, or volt-ampere characteristic of a single transient with a time resolution of fractional parts of millionths of seconds. This was the tool needed to give impetus to the study of lightning and lightning protection. It was soon applied to laboratory and field investigations, securing data not possible in any other manner.

Beginning in 1924 the tempo of investigation increased rapidly, with the introduction of the klydonograph, and

three years later the surge voltage recorder, both instruments designed to record transient voltages through the use of Lichtenberg figures. Polarity and frequency of occurrence were also recorded. With these instruments connected to transmission lines through capacitance potentiometers, many operating companies began collecting data to be correlated with tripouts, flashovers, and physical characteristics of the circuits and structures involved.

The impulse generator limitations were removed in 1925 with the use of the Marx circuit, with which capacitors are charged in parallel with direct current and discharged in series, all being accomplished through a judicious use of gaps, resistors, and a trigger circuit. This development eliminated the use of the high-voltage transformer with its large power supply, charging now being done at rated capacitor voltage using high-voltage rectifiers. Good control of wave shape and polarity was obtained. The voltage limitation also disappeared except as determined by the size of the laboratory building and the amount of money available. This new type of impulse generator could be readily taken out of doors, and with the portable cathode-ray oscillograph tests on transmission lines became feasible.

By 1930 several lines of investigation had been clearly identified, which included the study of natural lightning effects on transmission lines, effects of wave travel over transmission lines and distribution circuits, laboratory tests, and the development of types of lightning arresters whose characteristics were fixed and predictable.

Several electrical utilities, chiefly the American Gas and Electric and the Electric Bond and Share Companies, in co-operation with the two largest electrical manufacturing companies, had made considerable progress in investigating the lightning performance of overhead ground wires with different configurations and grounding arrangements. Measurements also had been made of transient voltages appearing on transmission lines resulting in data on attenuation as well as crest potential, together with some records of traveling waves due to lightning taken with the cathode-ray oscillograph.

To study wave travel on lines, the manufacturers and utilities co-operated using portable cathode-ray oscillographs and impulse generators. These tests gave much information on the effect of terminal impedances, lightning arresters, cables, transformers, choke coils, effect of ground resistance, surge impedance, length of leads, and other related factors. One of the first outcomes of these tests was the substantiation of the theory of traveling waves, followed by the discovery that the choke coil operated to increase the arrester voltage at the transformer rather than decreasing it, which had been the reason for its use. The choke coil was eliminated as a result of these tests.

In the laboratories of the manufacturing companies considerable progress had been made, as indicated by Peek in 1929 when he said: ". . . natural lightning waves have been reproduced in the laboratory where their effects on transmission lines, insulators, insulation, transformer and protective apparatus have been studied at will; a lightning generator producing over 3,600,000 volts has been constructed and waves from this generator have been sent over transmission lines to test full-size transformers and other apparatus to determine how to make them resistant to lightning; and scientific work on the time lag of gaps and insulation has been extended."

With the development of the Thyrite and the porous block types of lightning arrester, with cathode-ray oscillograms demonstrating their performance, a long step forward was taken in the building of confidence in the arrester as a protective means. However, the state of the art at that time was such that a considerable period of experience would be required, and more knowledge of transformer strengths and possible characteristics of lightning surges identified before there could be complete confidence in the ability of the arrester to do its job. Thus, we find Philip Sporn in 1930 saying with reference to building transformers strong enough to withstand lightning: "Today we know a little better. For example, we know roughly the possible order of magnitude of lightning voltages that may be impressed on station apparatus. We know it would be utterly unreasonable to expect a winding to withstand such voltages." Then, when discussing overinsulation of station apparatus as a means of operation, he said further: "This is perhaps the most expensive way of protecting terminal apparatus. On the other hand, in the absence of positive knowledge as to the efficacy of the lightning arrester, and agreeing that gaps fused or otherwise, or reduced insulation are unthinkable because of the service angle, it is apparent that this form of protection may be the only one available to the designer."

DEVELOPMENT OF THE LIGHTNINGPROOF LINE

But the picture was to change very rapidly in the next few years. The same lines of investigation were continued with the emphasis changing from the measurement of voltage by Lichtenberg figures to the measurement of current using the surge crest ammeter. In the 5-year period ending in 1935 more than 100 papers had been presented to the Institute by many different authors. By this time most of the data needed for the design of a lightningproof high-voltage line had been obtained. In fact, the design of the 287-kv double-circuit lines completed in 1936 from Hoover Dam to Los Angeles was good enough so that but three interruptions charged to lightning have occurred in the 13 years since the line was built. The original two tower lines were each equipped with two buried counterpoises, and 24 insulators were used to support the conductors. Subsequent experience has shown how to build less costly lightningproof lines.

Other lines at 220 kv and lower voltages have been built or modified as to spacing and location of ground wires and with properly co-ordinated ground resistances, so that a high degree of service reliability could be attained. The designer today, with knowledge available of the frequency of occurrence of lightning currents of various magnitudes and probable rate of rise of current, is able to design a line to be as safe from lightning as the economics of the situation demand. Methods of protecting wood poles and guys and yet maintaining the insulation strength of the wood are determined, and many such lines have given a good account of themselves. Protection of stations from

direct strokes by overhead ground wires or masts has demonstrated its value. The performance of cable, rotating equipment, transformers, lightning arresters, systems of protection, grounds, and transmission lines were all the subject of much investigation, thus acquiring a large amount of needed data.

Even before 1930 the Lightning Arrester, Lightning and Insulator, and Transformer Subcommittees of the AIEE were all actively engaged in studying the problem of what was required to bring order out of the chaotic condition existing in the broad field of protection of service and apparatus. Much work was done in establishing standard methods of test, standard wave shapes, and voltages for testing transformers, lightning arresters, and other devices. In 1941 the triple joint committee of AIEE, National Electrical Manufacturers Association, and Edison Electric Institute published a system of basic insulation levels for apparatus which were related to the lightning arrester levels of protection as established by the AIEE Lightning Arrester Subcommittee. These levels have been used by the industry ever since and are a forceful recognition of the principle that it is sound engineering to develop reliable protection and then design apparatus to operate with such protection, with a proper margin of safety.

Today more and more utility operators are following the practice, with high-voltage solidly grounded neutral systems, of using a reduced lightning arrester and a transformer with a basic insulation level one step below that normally used, following a practice established by the American Gas and Electric Company more than ten years ago.

Our story was now complete with one exception. What were the numbers which belong to lightning itself; how much current; how long did it last; what were the wave shapes and how often did they occur? The problem was to get in series with the lightning stroke itself, and so in 1937 the investigation of lightning strokes to the Empire State Building in New York began. Special oscillographs and cameras were used, from which much has been learned about the characteristics of lightning in terms of time and current, as well as data on the mechanism of the lightning stroke itself. This work was supplemented later by investigations to tall structures using the fulchronograph. The results agree quite well, and it now seems that sufficient data have been obtained to answer most of the questions concerning the characteristics of lightning as it relates to the operation of electric power systems.

Thus, we come to the end of a most remarkable demonstration of an industry solving a very serious limitation to its service to the public in the short space of about 15 years through a voluntary mobilization of its engineering personnel and its facilities, once the necessary instrumentation became available.

Recognizing a serious threat to service, the larger companies, both utilities and manufacturing, having the facilities, manpower, and know-how, set about solving the problem. These combined efforts were to yield results of great value to all companies both large and small, whether competitors or not. To me this is an excellent illustration of how the free enterprise system within a democracy can operate without any edicts or compulsions, performing on the general principle that whatever is beneficial for the industry is therefore beneficial for all of us.

New Portable Radiation Detector

A new portable radiation detector, the long-probe Gamma Survey Meter, which enables the operator to measure radioactivity from a distance of four feet, has been developed by the General Electric Company. The instrument can be used for monitoring areas in which radioactivity is suspected or for other types of radiation metering.

A detector, located at the end of the 4-foot-long probe, converts radioactive emanations into electric energy. This detector consists of an electronic tube and a phosphor, a material which gives off light in the presence of radioactivity. Light from the phosphor acts upon the electronic tube, where it is converted into electric energy.

At the other end of the instrument, a dial is activated by the energy from the tube, registering the amount of radiation impinging on the phosphor. The detector is powered by 1,000 volts induced from low-voltage batteries, which are enclosed in a portable box.

In Figure 1, Charles Lemmond, G-E engineer, is using the instrument to monitor a laboratory safe containing radioactive isotopes, which are enclosed in a heavy metal canister and surrounded by lead bars.

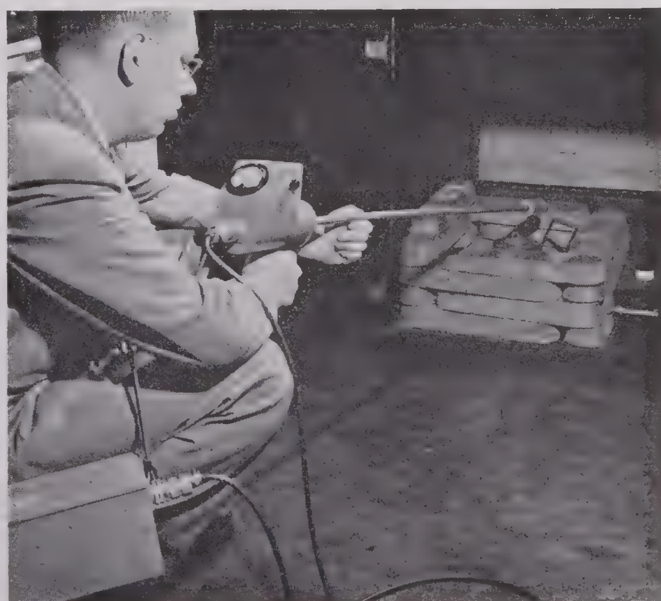

Figure 1. Monitoring radioisotopes with Gamma Survey Meter

Revising Tests for Transformer Insulation

F. J. VOGEL
MEMBER AIEE

THE MARGINS obtained and the degree of co-ordination between transformers and other insulation in transmission systems depends largely on the possibilities inherent in the insulation design of the transformer. Recently some units have been designed which take full advantage of the impulse characteristics of insulating materials as compared to their 60-cycle strengths. These designs are core-form, or at least have concentric coils, and it is likely that they might be considered to have maximum impulse characteristics compatible with present 60-cycle test requirements. It is believed that these characteristics affect and should be given consideration in the setting of future required impulse levels and tests, and perhaps in the 60-cycle tests which are required.

EXTREMES IN INSULATION CO-ORDINATION OF TRANSFORMERS

Impulse tests now are partly based on the basic insulation levels. The basic insulation levels which have been set up for use in determining impulse voltage levels for apparatus and transformers are full-wave levels only. These values are above the voltages ordinarily required to discharge through lightning arresters, so that protection to transformers is afforded by the use of lightning arresters with a margin as a general rule. However, there are extreme cases in service, where arresters are not used, or where the station and line protection is such that extreme lightning currents or voltages can occur. These latter cases are more often found in the case of voltages of 69 kv and below.

It would seem that in these latter cases, the use of full waves only as basic insulation levels is not adequate. In the past, for transformers, chopped-wave tests about 15 per cent higher in voltage than the basic insulation levels have been used, and in some cases steep-front tests have been applied. These steep-front tests consisted of waves rising at a rate of 1,000 kv per microsecond and flashing over a specified rod gap, or were obtained by the specification of a voltage value and a time to flashover.

Two considerations determine what should be done in such cases. One is what would be desirable, ideally. It is believed that the ideal situation has not changed too greatly since the subject was discussed in 1929 or 1930, that the windings should be stronger than the bushing or the other insulation immediately in front of the transformer. This in turn means that, although other parts might fail, the transformer windings should be invulnerable. The other consideration is what can be obtained economically.

Tests on 15-kv, 34.5-kv, 69-kv, and 138-kv insulation show that steep-front tests up to levels established by National Electrical Manufacturers Association are easily met and are economical. These tests would permit the use of gaps to give full protection to transformers; they also indicate that under extreme conditions arresters properly applied would provide nearly perfect protection. In fact, for the bushings used, the windings were definitely stronger than the bushings for the steepest waves applied. Therefore, it would seem likely that the ideal situation could be obtained.

On the other hand, it is likely that many lightning surges are limited by the arrester to the equivalent of full waves. If they always are, the tests required should be only full wave values. Consequently, the extreme strengths obtained in the tests described would not be necessary. Two separate parts of a transformer are involved, the major insulation and the winding insulation. The major insulation is determined by the 60-cycle tests to ground and the impulse tests. The winding insulation is determined by the impulse tests alone. If the impulse tests were reduced, only the winding insulation would be affected, and the decrease in insulation would not be great since reactance cooling and other considerations are also involved. If the impulse tests are reduced, reduction in the major insulation, or the 60-cycle tests to ground, would seem to be in order, and would lead to greater economy in the use of materials.

Lines are now designed where there are practically no lightning failures. Stations can be so well protected that very low currents result. Perhaps the lightning arrester characteristics can be entirely relied upon in transformer design, and then it would seem definite that steep-front strength is unnecessary and reductions in 60-cycle strength and steep-front strength could be made provided the standards would permit.

The conclusions are that for line voltages of 69 kv and below, the transformers should be designed, and tests applied, to obtain full wave and steep front strengths according to present American Standards Association and National Electrical Manufacturers Association standards. Transformer failures would be practically nil under such conditions. For voltages of 115 kv and above, line and station protection methods are extremely effective. Hence lower impulse strengths would probably be safe, and both lower low-frequency tests and impulse tests could be applied. In this case, perhaps the steep-front strengths are not as vital, but if specified, even the worst service conditions would be safe for the insulation strength of the transformer.

Digest of paper **49-195**, "Extremes in the Insulation Co-ordination of Oil-Insulated Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

F. J. Vogel is with the Illinois Institute of Technology, Chicago, Ill.

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Direct Measurement of Bandwidth

C. R. AMMERMAN
ASSOCIATE AIEE

There are three methods which can be used to determine the equivalent bandwidth of a network. The squared frequency-response curve can be integrated mathematically or graphically, or the noise power output of the unknown network can be compared to that of a standard network. The equipment and techniques to be used in the latter, direct method of measurement are described here.

SINCE the field of communications had its beginning, the width of the band of frequencies that could be passed by any piece of equipment has been important. Advances in the field have put more rigorous demands on the fidelity of response of some systems, consequently requiring greater pass-bands, and at the same time progress has demanded that other systems become more and more selective with an appropriate limitation of pass-band. Notwithstanding, the specification of bandwidth is not standard, nor has its measurement been simplified greatly.

Traditional methods of bandwidth measurement are based on somewhat arbitrary specifications; for example, the frequency difference between the high and low frequencies at which the single-tone response provides half the power corresponding to the frequency of maximum response. Other definitions of bandwidth or cut-off frequency are used in special cases whenever they seem appropriate. The lack of standardization in this matter creates confusion which is only now being resolved by the concept of equivalent bandwidth. A review of this concept is given to facilitate discussion of the instruments described.

THE CONCEPT OF BANDWIDTH

In consideration of band-pass devices, it is often convenient to think of an ideal frequency-response curve. The response would be uniform between the cut-off frequencies, and zero above and below the cut-off frequencies. Figure 1*A* represents such an ideal case. Here f_1 is the low frequency cut-off, f_2 is the high frequency cut-off, and A_o is the amplification of the device in the pass band. (In this discussion amplification will be considered the magnitude of the ratio of the output voltage to the input voltage.) In the ideal case there can be no doubt about the meaning of the term bandwidth; it is simply f_2-f_1.

Figure 1*B* represents a generalized response curve of the type often found in actual practice. The amplification, instead of being either A_o or zero, is some function of frequency, $A_{(f)}$. There are no real cut-off frequencies, because the amplification approaches zero rather slowly at both extremes. The amplification A_o, is also somewhat indefinite. Often $A_{(f)}$ has a broad maximum, which is usually designated the amplification. Even if the maximum is sharp, as in a tuned network, the amplification is taken as the maximum value of $A_{(f)}$. If $A_{(f)}$ is irregular, it may be desirable to use a different definition of A_o, but for the purposes of this article A_o will be defined as the maximum value of $A_{(f)}$.

The specification of bandwidth of this network is more difficult. Previous methods have followed the procedure of deciding how much variation of $A_{(f)}$ is significant and placing the frequency limits at these points, for example f_a and f_b. (Half-power points are often used.) Since the determination of significant variation is usually subjective, this is not very satisfactory. Another important point in the specification of bandwidth arises in connection with the acceptance of noise by a receiver. The bandwidth of the receiver determines the noise power in the output, and consequently affects the signal-to-noise ratio.

For all these reasons it is desirable to specify bandwidth in terms of the ideal response shape of Figure 1*A* which is equivalent to the practical response shape of Figure 1*B*. This equivalence is based on the power output resulting from a random noise input.

RANDOM NOISE

Random noise, fluctuation noise, or "white" noise has a constant power density spectrum. That is, it is composed of equal components of voltage of all phases and

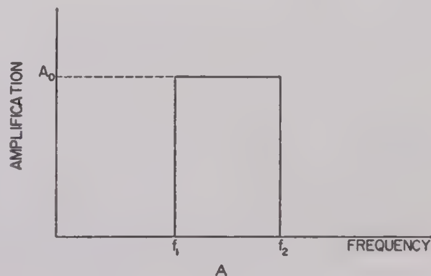

Figure 1(A). Frequency response of idealized band-pass network

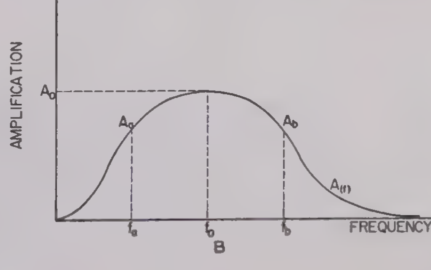

Figure 1(B). Frequency response of practical network

Full text of paper **50-5**, "The Direct Measurement of Bandwidth," recommended by the AIEE Joint Subcommittee on Electronic Instruments and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

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Appreciation is expressed to Dr. V. M. Albers and Dr. A. H. Waynick for their interest and aid in this problem.

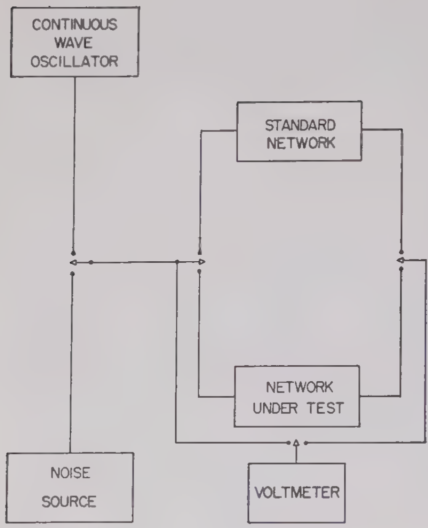


Figure 2. Block diagram of apparatus used for direct measurement of bandwidth shows that the variable-frequency oscillator and the noise source are arranged so that their inputs are the same. The voltmeter is the type to indicate proportional readings of rms values of noise-frequency voltages

frequencies. A random noise may be produced in several ways, all of them exploiting the randomness of certain electronic phenomena. Shot noise and thermal agitation noise are examples; other sources will be discussed later, but the point is noise can be produced having a uniform spectrum over a range sufficiently wide for most measuring purposes. Mathematically random noise can be written

$$e=E\sin[\omega_0t+\phi_0]+E\sin[(\omega_0+\Delta\omega)t+\phi_1]+E\sin[(\omega_0+2\Delta\omega)t+\phi_2]+ E\sin[(\omega_0+3\Delta\omega)t+\phi_3]\ldots\ldots+E\sin[(\omega_0-\Delta\omega)t+\phi_{-1}]+ E\sin[(\omega_0-2\Delta\omega)t+\phi_{-2}]+E\sin[(\omega_0-3\Delta\omega)t+\phi_{-3}]\ldots\ldots \quad (1)$$

where E is the magnitude of one of the harmonic components (all equal), $\Delta\omega$ is the radian frequency difference between components, and ϕ_n is a completely random phase angle.

A very thorough discussion of the statistical character of random noise has been written by S. O. Rice[1]; E. B. Moullin[2] presents the physical side of many noise phenomena.

EQUIVALENT BANDWIDTH

The equivalence of the practical and ideal networks regarding response to random noise or uniform power spectrum is developed by equating the noise power outputs. If a single tone of voltage E and frequency f be impressed on a practical network, the output power will be $E^2A^2_{(f)}/R_1$ where R_1 is the termination of the network. Also n single tones will produce a voltage of $\sum^{n} E_n^2A_{(f)}^2/R_1$. A noise spectrum will have an infinite number of equal components and the power output will be

$$P_o=\int_0^\infty \frac{E^2A_{(f)}^2}{R_1}\,df \quad (2)$$

The ideal network will be similar except that the integral will be zero between 0 and f_1 and between f_2 and ∞. Between f_1 and f_2 the amplification is A_o. For this case

$$P_o=\int_{f_1}^{f_2} \frac{E^2A_o^2}{R_1}\,df \quad (3)$$

A_o for the ideal network is equal to A_o, or the maximum value of $A_{(f)}$, for the practical network.

Equating the power outputs and eliminating E and R_1, which are not functions of frequency and are the same for both networks,

$$\int_0^\infty A_{(f)}^2df=\int_{f_1}^{f_2}A_o^2df=A_o^2(f_2-f_1) \quad (4)$$

Hence the two networks are equivalent if

$$(f_2-f_1)=\int_0^\infty \frac{A_{(f)}^2df}{A_o^2} \quad (5)$$

That is, f_2-f_1 is the equivalent bandwidth of the practical network.

To determine equivalent bandwidth using this definition it is necessary to perform the integration of the squared frequency-response curve. This can be accomplished in three general ways.

First, of course, the integration can be accomplished mathematically if the mathematical form of $A_{(f)}$ is known and if the integration can be carried out. One example of this is a pentode supplying a parallel resistance-capacitance circuit with essentially constant current. Mathematical evaluation of equation 5 gives Bandwidth $=1/(4RC)$. For more complicated cases the difficulty of this process becomes excessive.

A graphical-mechanical method can be used to perform the integration. A graph of $A_{(f)}^2$ is plotted, point by point,

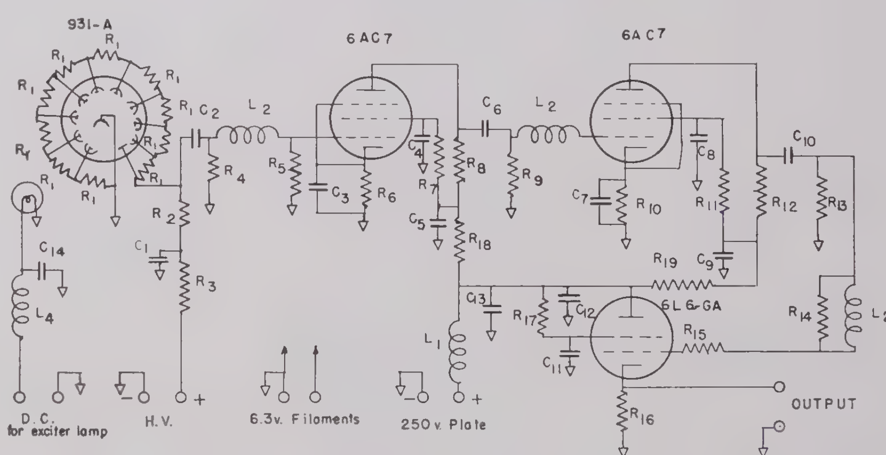


Figure 3. Schematic wiring diagram of noise generator

R_1 = 39,000 ohms
R_2 = 12,000 ohms
R_3 = 10,000 ohms
R_4 = 22,000 ohms
R_5 = 3,300 ohms
R_6 = 650 ohms
R_7 = 55,000 ohms
R_8 = 6,900 ohms
R_9 = 12,000 ohms
R_{10} = 150 ohms
R_{11} = 55,000 ohms
R_{12} = 6,900 ohms
R_{13} = 12,000 ohms
R_{14} = 4,700 ohms
R_{15} = 47 ohms
R_{16} = 1,250 ohms
R_{17} = 9,200 ohms
R_{18} = 4,700 ohms
R_{19} = 4,700 ohms
C_1 = 0.1 microfarad
C_2 = 0.00025 microfarad
C_3 = 0.1 microfarad
C_4 = 0.1 microfarad
C_5 = 0.1 microfarad
C_6 = 0.0003 microfarad
C_7 = 0.1 microfarad
C_8 = 0.1 microfarad
C_9 = 0.1 microfarad
C_{10} = 0.0003 microfarad
C_{11} = 0.1 microfarad
C_{12} = 0.1 microfarad
C_{13} = 8.0 microfarads
C_{14} = 0.001 microfarad
L_1 = 10 henrys
L_2 = Peaking coil
L_4 = 250 millihenrys

using data obtained with a continuous wave signal. The area is then found by counting squares or using a planimeter. The effective bandwidth is this area divided by the maximum value of $A_{(f)}{}^2$. This system is widely used but is tedious and time-consuming, and therein lies its disadvantage.

The third general method is to set up the unknown network and compare its noise power output to that of a standard network. By properly doing this, the bandwidth may be measured directly. The block diagram showing the needed apparatus is shown in Figure 2. The continuous-wave variable-frequency oscillator and the noise source are arranged so that the input to the two networks will be the same. The voltmeter reads the output voltage of either network using either source. The voltmeter must be suitable for the measurement of noise voltages; that is, its frequency range must be sufficient to encompass all components in the output of either network and its indication must be proportional to power or rms voltage.

If a certain noise voltage E_i is applied to the standard network, the voltmeter reading will be

$$E_{vs}{}^2 = E_i{}^2 A_{os}{}^2 BW_s \tag{6}$$

E_i is the noise input voltage, A_{os} is the maximum amplification of the standard, and BW_s is the bandwidth of the standard. If the same noise voltage is applied to the network being tested, the voltmeter reading will be

$$E_{vx}{}^2 = E_i{}^2 A_{ox}{}^2 BW_x \tag{7}$$

Here A_{ox} is the maximum amplification of the unknown and BW_x is the bandwidth of the unknown. The ratio of these is

$$\frac{E_{vs}{}^2}{E_{vx}{}^2} = \frac{A_{os}{}^2\, BW_s}{A_{ox}{}^2\, BW_x} \tag{8}$$

Solving for the bandwidth of the unknown,

$$BW_x = \frac{E_{vx}{}^2}{E_{vs}{}^2}\,\frac{A_{os}{}^2}{A_{ox}{}^2}\, BW_s \tag{9}$$

The ratio $A_{os}{}^2/A_{ox}{}^2$ is the ratio of the voltmeter readings of the two networks using for each network the frequency of maximum amplification (input voltage constant). The ratio $E_{vx}{}^2/E_{vs}{}^2$, as in the foregoing, is the ratio of voltmeter readings with equal noise voltages. BW_s is calculated by the graphical-mechanical means outlined previously.

General requirements for the measuring equipment having been set, consideration will now be given to the specific items of equipment. Each of the units shown in Figure 2 is discussed separately; connection and switching is accomplished by a coupler-comparator unit.

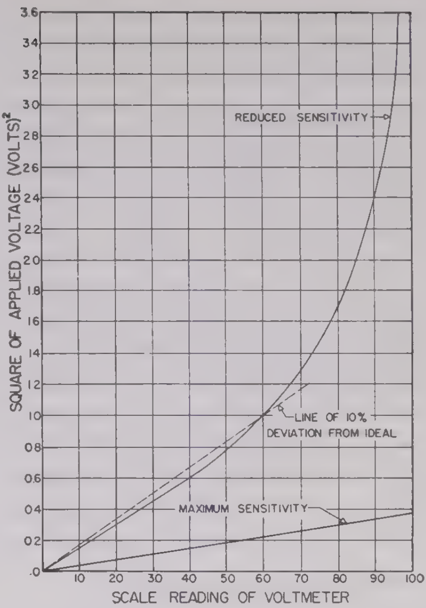


Figure 5. Calibration curves of voltmeter with sinusoidal input voltage show that the deviation from the square law increases slowly. If it is desired to keep within ten per cent deviation at the peaks, a 1.4-volt peak is allowable. By operating at mid-scale and maximum sensitivity the rms voltage is approximately 0.44 volt

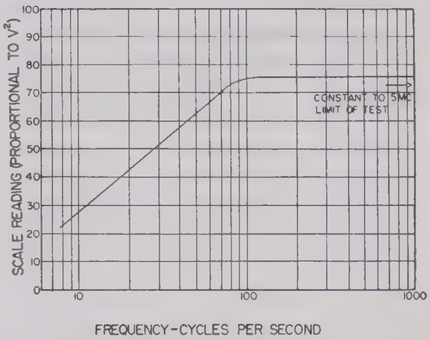


Figure 6. The frequency response curve of the voltmeter indicates that it is uniform over a range broad enough for the network being tested

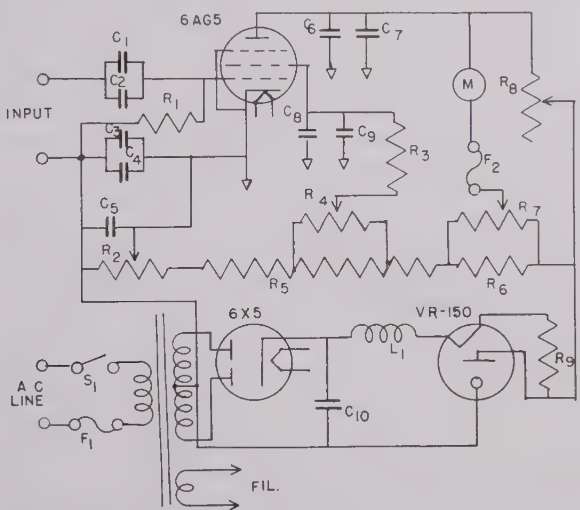


Figure 4. Schematic wiring diagram of voltmeter

R_1 = 1 megohm	M = 100-microampere d-c ammeter
R_2 = 100 ohms	C_1 = 0.0005 microfarad
R_3 = 500 ohms	C_2 = 0.01 microfarad
R_4 = 10,000 ohms	C_3 = 0.0005 microfarad
R_5 = 4,800 ohms	C_4 = 0.01 microfarad
R_6 = 25 ohms	C_5 = 25 microfarads
R_7 = 200 ohms	C_6 = 0.0005 microfarad
R_8 = 2,000 ohms	C_7 = 0.5 microfarad
R_9 = 2,000 ohms	C_8 = 0.0005 microfarad
F_1 = 1-ampere fuse	C_9 = 0.5 microfarad
F_2 = 1/200-ampere fuse	C_{10} = 8 microfarads
S_1 = Single-pole single-throw switch	L_1 = 10 henrys

Transformer: 110 volts primary; 250–0–250 volts and 6.3 volts secondaries

NOISE GENERATOR

There are many suitable sources of noise, each having its own peculiar advantages and disadvantages. The ultimate choice of the noise source will probably be a matter of convenience and availability, and in this case a noise generator from a modulator for a radar jamming set used by the Armed Forces proved to be the most con-

venient starting point. Certain modifications were made to make it more useful, and the complete circuit is shown in Figure 3.

The photoelectric-cathode secondary-emission multiplier tube is a source of fairly high-level noise. Noise in a photoelectric diode is similar to the shot noise in a temperature-limited diode. The rms noise current is[3]

$$I=\sqrt{2eI_{dc}\Delta f} \text{ amperes}/\sqrt{\text{cycles}} \quad (10)$$

where e is the charge on an electron, I_{dc} is the average current, and Δf is the bandwidth. This noise is amplified and slightly augmented in the multiplier sections.[5] Consider a type 931-*A* tube with a current amplification of 10^6 and a maximum d-c anode current of 10^{-3} ampere at rated conditions. The photocathode current is therefore 10^{-9} ampere at rated conditions, and the noise component in the photocathode current is

$$I=5.6\times10^{-12} \text{ ampere}/\sqrt{\text{kilocycles}}$$

This is amplified by 10^6 and slightly increased, so that this may produce a noise current of 6×10^{-6} ampere/-$\sqrt{\text{kilocycles}}$ in the anode circuit. Suppose the anode load resistance is 3,000 ohms; this will produce a noise voltage of 18 millivolts per $\sqrt{\text{kilocycles}}$. Very little amplification is necessary to make this useful for present purposes. The circuit in Figure 3 shows two stages of video amplification and a cathode-follower output stage.

The frequency range of this generator is important. The high-frequency response of the video amplifiers is good to nearly four megacycles. The low-frequency response is poor, particularly because of the coupling circuit between the 931-*A* and the 6*AC*7, for which the 3-decibel point is approximately 42 kilocycles. This did not constitute a serious objection in the work done in this case; however, it is believed that a noise generator with uniform output down to one kilocycle would be desirable should another noise source ever be built.

The output in a generator of this type can be controlled by varying three quantities: the current through the exciter lamp, the voltage on the secondary-emission multiplier, or the gain of the amplifier. Both of the first two methods described were used in this work.

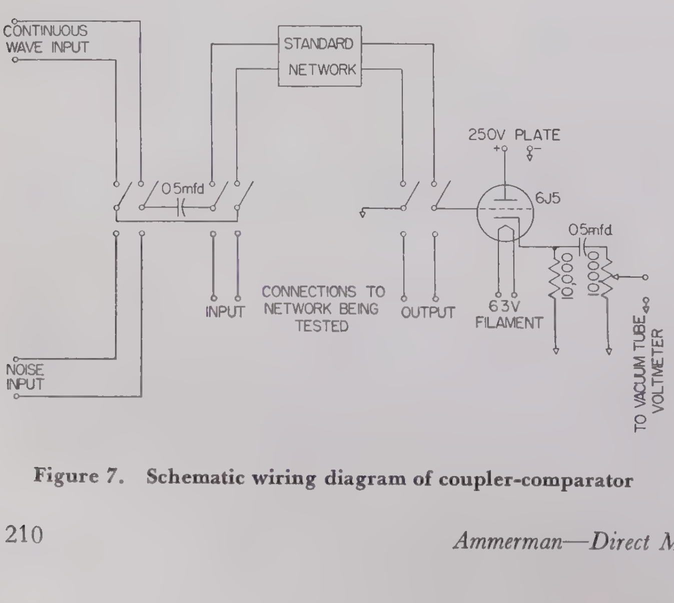


Figure 7. Schematic wiring diagram of coupler-comparator

One distinct disadvantage of the secondary emission multiplier is the change in amplification with the change in multiplier voltage. Examination of the published curves for the 931-*A* reveals that a reduction of five per cent from rated voltage results in a reduction of 30 per cent from rated amplification. Close control of anode voltage during a test is therefore necessary.

CONTINUOUS WAVE GENERATOR

Any signal generator with frequency range including the frequencies of maximum response of standard and unknown networks, and having sufficient output voltage, may be used here.

VOLTMETER

A voltmeter of wide frequency range, reading rms values (or proportional to the average power) must be used in this setup. In the voltmeter constructed, use is made of

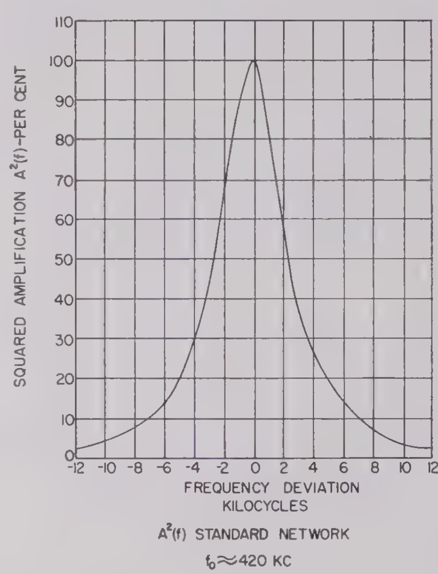


Figure 8. The squared amplification versus frequency characteristic for the network which was used as the standard. Other transformers and one network of resistors and capacitors were measured using this standard

the non-linear region of the grid voltage-plate current characteristics. By proper selection of the operating range, a characteristic is obtained of such nature that the meter deflection is proportional to the square of the input voltage.

The instrument is based on a square-law voltmeter described by J. R. Ragazzini and B. R. Boymel.[4] A few minor changes were incorporated, and the circuit is shown in Figure 4.

The criterion for square-law operation is that the grid voltage-plate current curve shall be expressible by the equation

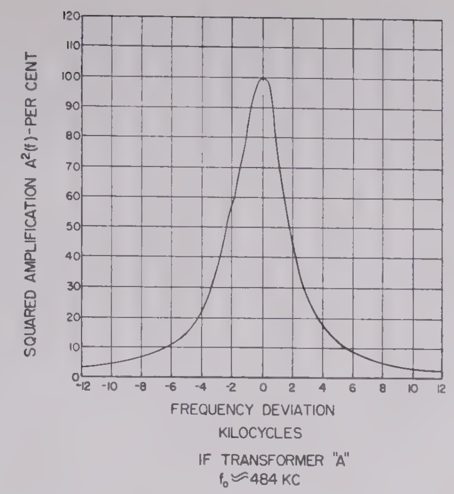
$$I_p=I_0+aE_g+bE_g^2 \quad (11)$$

The simplest way to locate this region is to make use of a mutual conductance bridge.

$$g_m=\frac{\partial I_p}{\partial E_g}=a+bE_g \quad (12)$$

If g_m is plotted against E_g, the region where the graph is a straight line will be the region where equation 11 is satisfied. Since it is reasonable to expect negative variations as great

Figure 9. Squared amplification versus frequency for one of the intermediate-frequency transformers tested by the use of the standard transformer



as positive variations, the grid bias is set in the middle of this region. For the tube used, a bias of -1.7 volts is necessary.

The range of the voltmeter is shown in Figure 5. Here the deflection is plotted against the square of the rms value of a sinusoidal input voltage. It is seen that deviation from square law increases slowly. It was felt that a 10-per cent deviation at the peaks would not be detrimental; in that case the range of the instrument is approximately 1.0 volt rms or 1.4 volts peak. If the voltmeter is operated at maximum sensitivity and approximately midscale, the rms voltage is approximately 0.44 volt compared to 1.4 volts peak allowable.

The probability of the absolute value of instantaneous noise voltage exceeding a value r times the rms value is given by[6]

$$p=1-erf\left(\frac{r}{\sqrt{2}}\right) \tag{13}$$

where erf is the error function. If $r=1.4/0.44$, $p=0.00146$. That is, the noise voltage will exceed the voltmeter range only approximately 1/700 of the time. It is felt that serious error is not caused by neglecting these peaks.

It is required that the voltage response be uniform over a range at least broad enough to include any appreciable response in the network tested. Figure 6 shows the frequency characteristic for this voltmeter, and it is seen to be adequate.

COUPLER COMPARATOR

In order to perform the switching necessary without undue confusion, and to couple the output of the network to the voltmeter, a coupler comparator unit is used. The complete schematic diagram is shown in Figure 7. The standard network should match as closely as possible the network being tested in order to assure maximum accuracy. A set of plug-in standard networks would be highly desirable.

The input to the network has low impedance and the output has high impedance. If the network is designed for other terminations, these terminations can be taken into account and proper impedances used when the network is connected to the input and output terminals.

It is possible to use a fiducial mark on the voltmeter and calibrate a potentiometer gain control in the coupler comparator to read the ratios A_{os}^2/A_{ox}^2 and E_{vx}^2/E_{vs}^2. It is necessary, in that case, to be most careful of capacitive loading of the potentiometer in order to prevent modification of the high-frequency characteristics as gain is changed.

EXPERIMENTAL RESULTS

The experimental work done with this apparatus consists of measuring the bandwidth of several networks directly, and comparing this result with the bandwidth obtained by actually plotting the $A_{(f)}^2$ curve of each network and using the graphical-mechanical method.

Most of the networks measured were simple double-tuned intermediate-frequency transformers. One transformer of rugged mechanical design was selected as the standard, and its bandwidth was found by the graphical-mechanical method. The $A_{(f)}^2$ curve of this network is shown in Figure 8. Using this standard, several other intermediate-frequency transformers and one network of resistors and capacitors were measured directly. The $A_{(f)}^2$ curve of each network was also plotted and the bandwidth by the graphical-mechanical method was determined

Table I. Comparison of Results of Measurement of Equivalent Bandwidth

Network	f_o, kc	Bandwidth, kc Graph*	Bandwidth, kc Direct
Standard	420	7.6	
Intermediate-frequency transformer *A*	484	5.8	5.8
Intermediate-frequency transformer *B*	420	7.6	7.6
Intermediate-frequency transformer *C*	500	4.8	4.7
Resistance-capacitance network	65	240	220

* By the graphical-mechanical method.

to check on the direct method. Figure 9 shows a typical $A_{(f)}^2$ curve for one of the intermediate-frequency transformers tested.

Figure 10 shows the $A_{(f)}^2$ curve and the circuit of a resistance-capacitance filter tested. Table I gives the statistics of these tests and shows that the agreement is

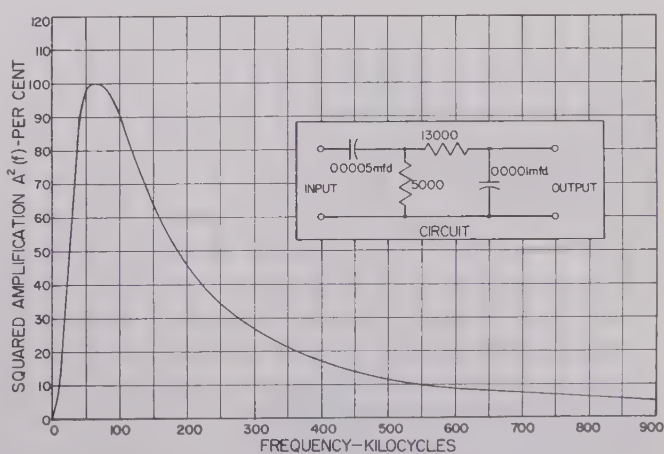


Figure 10. Squared amplification versus frequency for network of resistors and capacitors

very good. No attempt to go beyond two significant figures was made because of the limitations of the equipment at hand.

CONCLUSIONS

From the foregoing data it can be seen that the direct measurement of equivalent bandwidth is possible. The percentage difference between the values of bandwidth obtained by this method and by the graphical-mechanical method are quite small.

If this equipment were to be used for routine or versatile measurements of filter bandwidths, certain obvious improvements could be made. The equipment which is needed, however, is actually relatively simple and straightforward.

This method could be used for the production testing of filters to check bandwidth within tolerances, or for the laboratory testing of miscellaneous networks of which bandwidth is an important parameter. Refinements of this method may be developed which would make possible the testing, as a 4-terminal network, of a complete system, such as a radio receiver or a complete telephone cable circuit.

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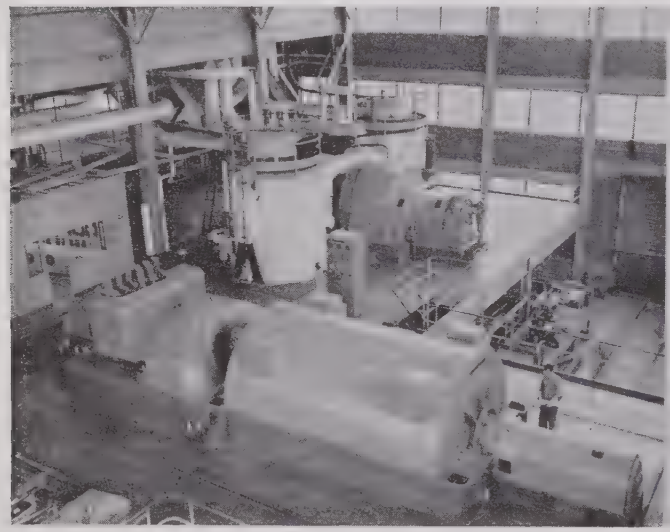
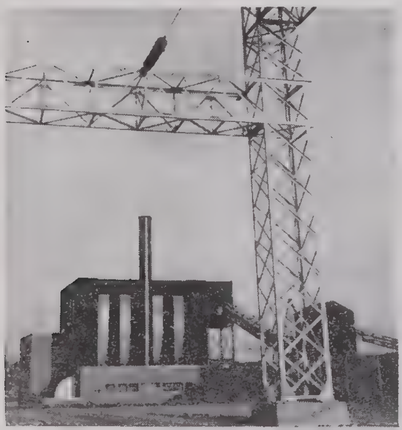
40,000-Kw Station Uses Mercury-Vapor and Steam-Driven Generators



Turbine room, left, showing the 25,000-kw steam turbine generator in foreground, and right, boiler and turbine control room



Outside view of the Schliller Station

Schliller Station, opened in Portsmouth, N. H., in January, by Public Service Company of New Hampshire, derives its power from the combined use of mercury-vapor and steam-driven turbine generators built by the General Electric Company. The new 40,000-kw station consists of two 7,500-kw mercury turbine generators, two mercury boiler furnaces, two heat exchange units called condenser-boilers, and a 25,000-kw steam turbine generator. Heat for the mercury boiler furnaces can be supplied by the burning of either pulverized coal or Bunker "C" oil, lowest commercial grade of fuel oil. When the plant operates on oil, the fuel flows by gravity from the main storage tanks into a 3,000-gallon station tank located in a concrete vault at the western end of the building, is then pumped from the tank through a fuel heating system, metered, and finally burned in the boiler furnace. When operating with coal, crushed coal from the storage yard is brought into the station on an inclined belt conveyor to a 1,000-ton coal bunker. Coal from this bunker is pulverized, and fed to the furnaces.

Differential Leakage of a Fractional Slot Winding

M. M. LIWSCHITZ
MEMBER AIEE

WHEN the conditions for balance are satisfied, a fractional-slot lap winding can be laid out in many different patterns, all of which are balanced. The usual pattern is that for maximum distribution factor of the main wave. If this pattern is called the "basic," all other patterns can be derived from this one by cyclic shifts of coils from one phase to the other within the same repeatable group. The distribution factor of the main wave of the derived patterns, that is, of the patterns with cyclic shift of coils, is always smaller than that of the basic layout. As regards the distribution factors of the harmonics of the derived patterns, some are smaller and some larger than those of the basic pattern.

It is generally assumed that the patterns with cyclic shift of coils have a smaller differential leakage than the basic pattern. It is shown in this article that this assumption is not correct and that the use of patterns with cyclic shift of coils is justified only when, with regard to noise or telephone interference, it becomes necessary to reduce one or several electromotive force or magnetomotive force harmonics. The differential leakage of a 3-phase fractional-slot winding is given by the equation

$$x_d=\frac{4}{\pi^2}mf_1N_{ph}^2\frac{\tau l_e}{pgk_ck_s}10^{-7}\times C \text{ ohms/phase} \tag{1}$$

with

$$C=\frac{\beta^2}{4}\sum_{\nu\neq\beta/2}\left(\frac{k_{dpn}'}{\nu}\right)^2 \qquad \nu=1, 2, 4, 5, 7\ldots \tag{2}$$

when β is an even number and

$$C=\beta^2\sum_{\nu\neq\beta}\left(\frac{k_{dpn}'}{\nu}\right)^2 \qquad \nu=1, 5, 7, 11\ldots \tag{3}$$

when β is an odd number. The meaning of the symbols is

m = number of phases
f = line frequency
N_{ph} = number of turns per phase
τ = pole pitch
l_e = effective core length
p = number of pole pairs
g = air gap
k_c = Carter factor
k_s = saturation factor
β = denominator of the fraction which fixes the number of slots per pole per phase
k_{dpn}' = distribution factor times pitch factor of the n'th harmonic
n' = order of the harmonic with respect to a fundamental, the wave length of which is equal to $2pt$

The cyclic shift of coils does not introduce new harmonics ν, nor does it change the pitch factors of the winding. It changes only the distribution factors k_{dn}'. Therefore, for a comparison of the differential leakage of the different patterns, it is sufficient to compare their magnitudes of C.

As an example, a 3-phase winding with $2^3/_8$ slots per pole per phase will be considered. The coil grouping of phase A for the basic layout of this winding is, in 8 poles,

3 2 2 2 2 2 3 3

Calculations were made for the basic layout and for three cyclic shifts of coils which yield the following coil groupings for phase A in 8 poles:

3	2	2	3	2	2	2	3	cyclic shift 1
3	2	3	2	2	2	3	2	cyclic shift 2
3	2	2	2	2	3	2	3	cyclic shift 3

The calculation shows that any cyclic shift of coils increases the distribution factors of the subharmonics while some of the distribution factors of the harmonics of higher order than the main wave are smaller, and others larger than those of the basic layout.

Table I. Relative Differential Leakage of a 3-Phase Winding With $2^3/_8$ Slots Per Pole Per Phase for Different Layout Patterns

W/τ	Basic Layout	Cyclic Shift 1	Cyclic Shift 2	Cyclic Shift 3
Without Subharmonics				
0.983	0.0218	0.0176	0.0182	0.0176
0.842	0.0186	0.0165	0.0170	0.0176
0.701	0.0175	0.0155	0.0172	0.0172
With Subharmonics				
0.983	0.0263	0.0458	0.0320	0.0286
0.842	0.0224	0.0374	0.0278	0.0259
0.701	0.0199	0.0307	0.0244	0.0241

Table I shows the quantity $C=16\sum_{\nu\neq 4}\left(\frac{k_{dpn}'}{\nu}\right)^2$, that is, the relative differential leakage, for the four different layout patterns at three different ratios of coil pitch W to pole pitch τ. It can be seen from this table that, with the subharmonics neglected, the differential leakage of the patterns with cyclic shift of coils is somewhat smaller than that of the basic layout and that, with the subharmonics taken into account, the differential leakage of the patterns with cyclic shift of coils is much larger than that of the basic layout. It is true that the harmonics of low order and especially the subharmonics, are more damped by a squirrel cage rotor or by eddy currents than the harmonics of higher order. However, no gain with respect to the differential leakage can be expected from the cyclic shift of coils for the winding considered.

The investigation of other numbers of slots per pole per phase shows results similar to those of the example, thus confirming that normally the basic layout should be used and the cyclic shift of coils should be applied only when one or several harmonics are to be reduced.

Digest of paper **49-235**, "Differential Leakage of the Different Patterns of a Fractional Slot Winding," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Frank Baldwin Jewett

Leader, Statesman, and Nobleman of Science

GANO DUNN
HONORARY MEMBER AIEE

Prior to his death on November 18, 1949, the Hoover Medal for 1949 was awarded to Dr. Frank B. Jewett (F '12, HM '45) with the citation: "Great pioneer of industrial research, leader in molding scientific and engineering work to the needs of humanity, distinguished organizer of scientific effort for the service of the nation in war and peace." The medal, which is a joint award of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the AIEE to an engineer "for distinguished public service," was presented posthumously during a session on Wednesday evening, February 1, of the AIEE Winter General Meeting in New York, N. Y., which was presided over by Scott Turner, Chairman of the Hoover Medal Board of Award. The medal was accepted by Dr. Jewett's eldest son, Harrison L. Jewett.

"AWARDED by engineers to a fellow engineer for distinguished public service." Such is the legend on the great medal of distinction which has been presented to Frank Baldwin Jewett, in sadness, because after the award was voted by the Hoover Medal Board of Award on November 1, 1949, death ended his career on November 18, 1949.

As life is measured, no judgment is so sweet as the judgment of one's peers. They are the ones who know strength and weakness, who measure character and performance, and whose verdict outweights all other verdicts. This judgment of Frank Baldwin Jewett was made by representative engineers from the four great national engineering societies: the American Society of Civil Engineers, The American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the AIEE. Its language reads as follows: "Great pioneer of industrial research, leader in molding scientific and engineering work to the needs of humanity, distinguished organizer of scientific effort for the service of the nation in war and peace."

PROFESSIONAL CAREER

Dr. Jewett was born in Pasadena, Calif., in 1879. His first technological education was in the field of electrical engineering at the Throop Polytechnic Institute, which later became the California Institute of Technology. Here he received the Bachelor of Arts degree in 1898, and then went for advanced study in physics, mathematics, and chemistry to the University of Chicago, where he was research assistant to that outstanding physicist, A. A. Michelson. He then attended the Massachusetts Institute of Technology where, from 1902 to 1904, he studied advanced electrical engineering and served as an instructor in physics and electrical engineering.

At the Massachusetts Institute of Technology his outstanding ability brought him to the attention of the men in charge of the new Research and Development Department of the American Telephone and Telegraph Company, then located in Boston, and he began an association with that company which, from 1904 on, was uninterrupted.

In 1907 the Research and Development Laboratories were moved to New York, where in 1912 Dr. Jewett was transferred to the Western Electric Company as Assistant Chief Engineer in charge of the newly formed Research Department and several related departments, retaining an informal connection with the American Telephone and Telegraph Company under those great pioneers John J. Carty and Bancroft Gherardi.

In 1925 he became Vice-President of the American Telephone and Telegraph Company, in charge of all development and research, and president of the then newly incorporated Bell Telephone Laboratories. Jewett and a corps of brilliant associates under his leadership made this into one of the greatest research institutions in the world, out of which has come a continuous stream of outstanding electrical and other inventions of transcendent importance to modern life.

HONORS

In 1936, Dr. James B. Conant, president of Harvard University, summed up Dr. Jewett's career when Harvard conferred upon him the honorary degree of Doctor of Science in a citation which reads: "Frank Baldwin Jewett of New York City, electrical engineer, president of the Bell Telephone Laboratories since 1925, the creator of a famous laboratory whence came miracles of modern telephony, an engineer who points the way for industry to follow."

In addition to his honorary degree from Harvard, honorary degrees were conferred upon Dr. Jewett by New York University, Dartmouth College, Columbia University, University of Wisconsin, Rutgers University, University of Chicago, Case School of Applied Science, and University of Miami.

His other honors are too numerous all to be mentioned.

Full text of an address citing the medalist's career which was given in conjunction with the Hoover Medal presentation ceremonies held during the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950.

Gano Dunn is President, The J. G. White Engineering Corporation, New York, N. Y., and President, Cooper Union for the Advancement of Science and Art, New York, N. Y.

In 1919 he received the Distinguished Service Medal in a citation which reads: "For exceptionally meritorious and conspicuous service with the development of the radiotelephone and the development of other technical apparatus for the Army."

In 1928 he received the AIEE Edison Medal; in 1935 the Faraday Medal of the Institution of Electrical Engineers of Great Britain; in 1936 the Franklin Medal of the Franklin Institute of Pennsylvania; and, in 1938, the Washington Award of the Western Society of Engineers.

In 1939 he also received the John Fritz medal, awarded jointly, as in the case of the Hoover Medal, by representatives of the four great national engineering societies. On the occasion of its presentation, Dr. Karl T. Compton, then president of the Massachusetts Institute of Technology and chairman of the John Fritz Medal Board of Award, described him as "one of that very small group who are the leaders, statesmen, and noblemen of science."

Dr. Jewett was president of the AIEE in 1922–23; president and trustee of the New York Museum of Science and Industry, to the development of which he made important contributions; a life member of the Corporation of the Massachusetts Institute of Technology; a trustee of the Carnegie Institution of Washington, the Woods Hole Oceanographic Laboratory, and Tabor Academy. Also, in his home town of Millburn, N. J., he was a member of the Board of Education and a director of the First National Bank.

It is doubtful if anybody in the past ever had such influence in teaching the leaders of industry the importance of scientific research and development. To the telephone company he demonstrated time and time again that the millions they spent annually on research were bread upon the waters, which was returned in economies in terms of tens of millions.

Other industries learned the lesson taught by the leadership of the telephone company and increasingly established research laboratories, until today an industry that does not have a research laboratory is on the way to decay and extinction.

WARTIME SERVICES

It was fortunate for the winning of the second world war that Frank Baldwin Jewett was elected in 1939 president of the National Academy of Sciences, the highest honor within the gift of American science. He was the first engineer ever to receive this honor, and to the post he brought not only his rich equipment as a scientist, but his vast experience in its industrial application.

As the clouds gathered and the nation entered the second world war, Dr. Jewett's capacity as an executive at the head of the National Academy of Sciences and its auxiliary the National Research Council was invaluable to the nation. He had the opportunity of bringing science and engineering to the support of the war to a unique and unparalleled extent.

In 1940 President Roosevelt appointed him to the Office for Emergency Management when that office was organized. In June of that year he became one of eight members of the National Defense Research Committee of the Office of Scientific Research and Development and was placed in charge of the research of that group in transportation, communications, and submarine warfare, directing its submarine warfare laboratories at New London, Conn.

Subsequently, he was a member of the co-ordination and equipment division of the Signal Corps, and consultant to the Army Chief of Ordnance. In 1944 he was one of 12 Army, Navy, and civilian members of a committee to create a high command in science equivalent in rank to the Army and Navy high commands.

At the request of the armed services, the next year he set up the Research Board of National Security, comprised of 20 civilian and 20 military scientists to continue the development of weapons.

He had the rare honor of being elected in 1943 for a second 4-year term as president of the National Academy of Sciences which charged him with the leadership of the enormously expanded services science was rendering to the national government in the winning of the war. Particularly after his retirement in 1944 from the American Telephone and Telegraph Company, which was compulsory at the age of 65, he devoted himself day and night to bringing about the success of the war as far as science and engineering, coupled with a vast industrial experience, could contribute to it.

Throughout this magnificent record, in addition to his service to the American Telephone and Telegraph Company, Dr. Jewett rendered public service of incalculable value. As far back as 1930 he was called "one of the ten men the world could least afford to lose."

A DISTINGUISHED CITIZEN

In giving consideration to candidates who have previously received the honor of the Hoover Medal, its successive Boards of Award have often pointed out that eligibility is not based on technical eminence alone. They have made clear that the medal is given to those who, in addition to technical eminence and accomplishment, have rendered conspicuous public service outside of their required professional duties out of a desire for the general welfare of their fellow citizens and because they have been imbued with devotion to the national interest and their country's good. In the career of Frank Baldwin Jewett these characteristics have been outstandingly conspicuous.

As a person, there was always about him an air of modesty and quiet distinction, an attitude of immediate and voluntary helpfulness to others wherever he learned of opportunity. His sweet and lovable character made him welcome wherever he went, and bound to him hosts of friends, not only in the fields of science and engineering, but in every walk of life. Disinterested and liberal, of acute intelligence and sensibility to humor, companionship with him was richly rewarded. The soul of honor in every commitment, to do business with him was a satisfaction and to be his friend an invaluable privilege.

His accomplishments were fully as much due to the leadership of his character as to the leadership of his mind; and in naming him as a suitable recipient, the Hoover Medal Board of Award has added distinction to the already great distinction of its honorable list.

Attenuation and Delay Equalizers

W. R. LUNDRY

THE ADJUSTABLE loss characteristics obtained in the A and B equalizers are shown by the curves of Figure 1. These curves show the maximum adjustment range above and below a reference loss which is approximately 40 decibels in each equalizer. Pairs of curves are identified by a number corresponding to the line-up frequency in kilocycles. The loss can be adjusted continuously or in small steps to fall on curves intermediate to those shown. All intermediate curves are approximately proportional to the limiting cases shown.

The A and B equalizers are complex assemblies of adjustable 2-terminal networks. Loss adjustment is obtained by changing the value of control resistances. These may be wire-wound and connected to a rotary switch for manual adjustment or they may be thermistors subject to control by a pilot frequency regulator.

In addition to its adjustable sections the A equalizer also contains a series of fixed loss sections which serve to equalize the accumulated fixed errors of 11 auxiliary repeaters. These are simple configurations of familiar equalizer types. In some cases they are associated with adjustable sections in order to reduce the over-all A equalizer loss to tolerable values.

Precise control of the electrical characteristics is required at each step of manufacture to insure meeting end-product limits of ± 0.13 decibels. Capacitance tolerances of ± 0.5 per cent and resistance tolerances of ± 1 per cent are required frequently. Resonant circuits are adjusted to frequency tolerances of ± 0.5 per cent and sometimes as close as ± 0.2 per cent by using slug-tuned inductors.

The B equalizer has 15 adjustable loss characteristics shown at the top of Figure 1. All adjustments are made by dials having 20 uniform loss steps.

In general, the loss characteristics of the B equalizer tend to be narrower and hence, to require a more precise setting of the resonant frequency of coil–capacitor combinations. For example, one of the B equalizer characteristics adjusts the loss over a band 200 kc wide centered at 3,030 kc where the resonant frequency must be adjusted to ± 6 kc or ± 0.2 per cent.

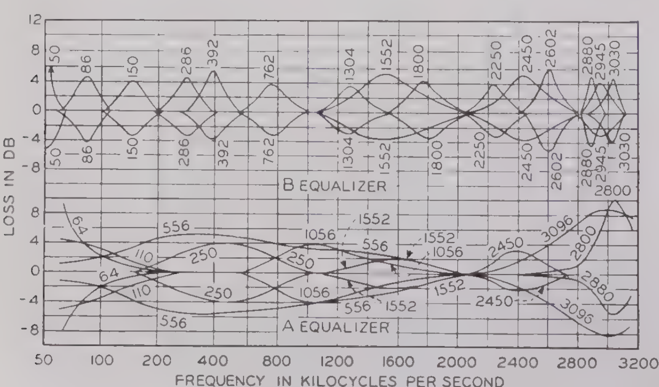

Figure 1. Adjustable loss characteristics of A and B equalizers

Since B equalizers are used less frequently in the circuit, wider end product limits are tolerable. The performance of the completed equalizer is checked by comparing its loss to that of a standard equalizer at the maximum and minimum settings of each of the 15 controls on a recording loss circuit. Limits of $+0.25$ decibels are set on these characteristics.

The designs of delay equalizers for this system follow the potential analogue method. To fit the inherently unbalanced nature of the coaxial circuit, unbalanced bridged-T sections are used to realize the design.

A family of six delay equalizers and two building-out networks has been developed. The largest of these contains 52 all-pass sections; the smallest, 8 sections.

Each of the 52 all-pass sections is assembled in its individual shield. Most of these contain two inductances and three capacitances arranged in conventional bridged-T configuration. The capacitances are manufactured to close tolerances, usually one-half per cent. The inductors contain threaded magnetic plugs which are used to adjust the inductance to resonate with the associated capacitors.

The critical frequencies of the sections, corresponding to the resonant frequencies of the series and shunt arms, are adjusted to an accuracy of ± 0.5 kc. At 3,000 kc this corresponds to a frequency accuracy of 0.017 per cent, or, in terms of the adjustable element, an inductance accuracy of 0.008 per cent.

The comparatively wide manufacturing variations encountered in the dissipation factor of the inductors makes it necessary to provide means for adjusting each one individually. This is done by adding two resistances external to the unit assembly at the time the resonance frequency adjustments are made. Selected resistance values are used to hold the loss of each section within ± 0.03 decibel of its nominal value.

The completed equalizers are tested for transmission loss and phase shift to insure a product uniformity of ± 0.1 decibel loss and ± 1 degree phase over the entire operating band. Input and output impedances of each network are required to have a reflection coefficient of less than five per cent against a 75-ohm resistance.

These limits are extremely close. However, they are barely adequate to insure satisfactory delay equalization of present-day television circuits 1,000 miles long (for example, New York–Chicago). Such circuits use approximately 30 equalizers distributed along the line and the cumulative effect of such manufacturing deviations is large.

Digest of paper **49-246**, "Attenuation and Delay Equalizers for Coaxial Lines," recommended by the AIEE Communication Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

W. R. Lundry is with the Bell Telephone Laboratories, Inc., Murray Hill, N. J.

Use of Germanium Diodes at High Frequencies

J. H. SWEENEY

Germanium diodes are now being used in many ways. In television sets they help to reduce size, weight, and number of tubes, and they eliminate filament hum which is prevalent with series filament wiring, reduce the heat from filaments, and eliminate many of the other drawbacks of conventional diodes. Germanium diodes are also used as mixers in place of silicon crystals.

THE PRICES of television receivers are being reduced almost continuously, and at the same time designers are striving to reduce their weight, size, and tube complement. Today, with engineers designing receivers for use on new ultrahigh-frequency channels, efficient, inexpensive converters are needed.

A major factor in the attainment of these goals is the increasing use of germanium diodes in place of vacuum tubes in many circuits. In addition to the reduction of size, weight, and number of tubes, germanium diodes also offer many other advantages. Filament hum prevalent with series filament wiring can be eliminated; heat from filaments can be reduced; feedback can be controlled more easily; longer, reliable life can be obtained, particularly for the ultrahigh-frequency converters, and in many cases greater output can be obtained.

Until several years ago, germanium as a semiconductor was little studied. During the war it came into prominence when it was investigated for possible use in mixers for ultrahigh-frequency reception. Today, commercially available diodes of minute size are used by the tens of thousands a week, and one of the fastest-growing markets is in television receivers.

Germanium, like boron, silicon, selenium, and others, is an element which exhibits properties of conduction intermediate between conductors and nonconductors in that its current voltage characteristic does not follow Ohm's law.

Figure 1 shows typical current-voltage characteristics of germanium diodes. The flow of electrons to one polarity of voltage on the diode is many times that of the flow to the opposite polarity.

FORMING THE DIODE

The germanium used in commercial diodes is obtained by reducing germanium dioxide in hydrogen ovens and forming germanium ingots. These ingots are sawed into pellets 0.050 inch square by 0.020 inch thick, and each one is soldered to a small brass pin with a tinned pigtail forming a pellet assembly. The rectifying property of the pellet assembly is obtained by point-to-plane contact. In the construction of General Electric diodes a fine platinum alloy wire 0.003 inch in diameter with a chisel point is used as a whisker. This wire, which is specially formed, is welded to a pin and tinned pigtail to form a whisker assembly. With the pellet assembly fixed in a plastic case, the whisker assembly is advanced into the case until contact is made, and then a current of several hundred milliamperes is passed through the diode to form a weld of the platinum wire to the germanium pellet. The unit is then cemented, vacuum wax impregnated, and classified according to test limits. A completed unit measures less than one-quarter inch in diameter and one-half inch long.

At present there are four general-purpose and two television classifications of the General Electric diodes. The general-purpose diodes are classified according to forward and back resistance and inverse peak voltage ratings. These are types *1N51*, *1N48*, *1N52*, and *1N63*, listed in order of increasing back resistance. The *1N64* is a television video detector grade, and the *1N65* is a television d-c restorer type.

The small physical size of the unit allows it to be soldered or clipped readily into any tight corner of a chassis assembly or even in a shielding can. Its insulated case removes any possibility of its contacting other circuit elements, and its welded construction makes it durable for rugged application requirements.

GERMANIUM DETECTORS

The most widely accepted application of germanium diodes in television receivers so far is as video detectors. The function of the video detector is to demodulate the high-frequency intermediate-frequency signal to obtain the video modulation. Until the present, the most common element used for this purpose has been half of a *6AL5* double-diode vacuum tube. With only minor circuit changes necessary, a germanium diode can be substituted for the vacuum-tube detector. The substitution, however, in many cases has led to the problem of how to eliminate the other half of the diode in order to dispense with the tube, its socket, and associated wiring. Where the problem was not solved in model redesign, another germanium diode could be used effectively.

There are several outstanding differences between germanium and vacuum-tube diodes that should be noted. The germanium unit has greater forward conductance than the vacuum tube which invariably is a distinct advantage. Yet, unlike the vacuum tube, it has finite back resistance which must be provided for in the

Full text of paper **50-71**, "The Application of Germanium Diodes in High- and Ultra-high-Frequency Television Receivers," recommended by the AIEE Committee on Television Broadcasting Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Not scheduled for publication in AIEE *Transactions*.

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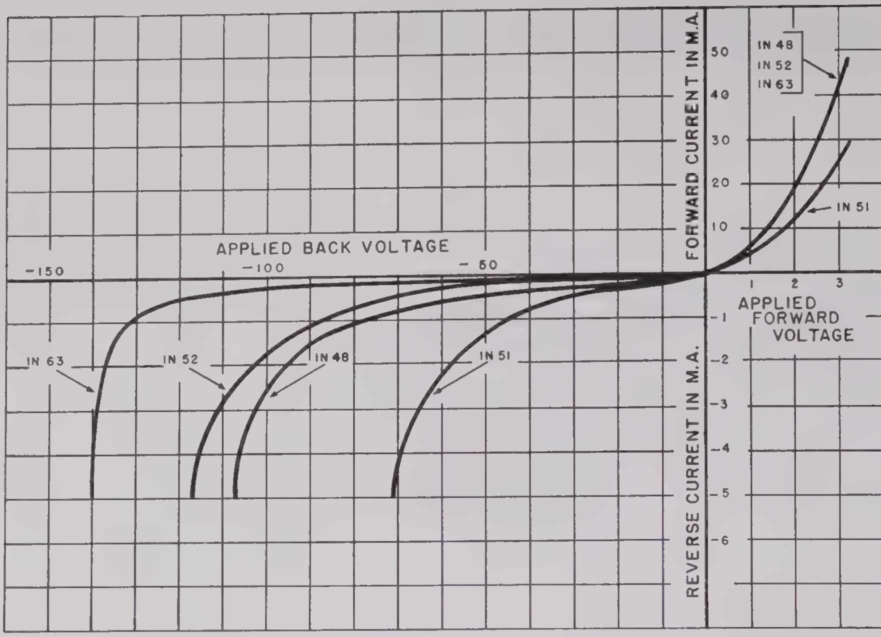


Figure 1. Typical current-voltage characteristics of type *1N48*, *1N52*, and *1N63* germanium diodes

circuit design. The germanium diode has less shunt capacity, and because it is a passive element it has zero current flow at zero voltage. Both of these characteristics are advantages. On the other hand, both the forward and back resistance of the germanium diode will vary with a change in temperature and will vary between units. As long as these properties are understood, however, their effect can be compensated for in the elements of circuit design.

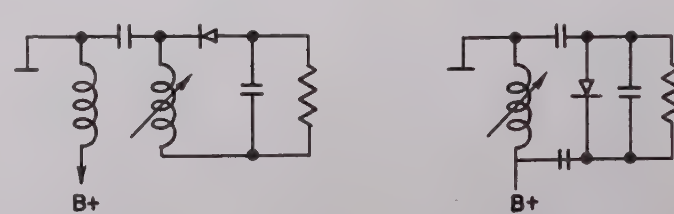
Consider the simple diode detector circuits shown in Figure 2. Figure 2*A* is a series-type circuit and Figure 2*B* is a shunt-type circuit. Both types of circuits are widely used and will perform equally well. The shunt circuit is used primarily when a closely coupled intermediate-frequency transformer is used in such a manner that capacitive coupling to the detector is necessary to prevent B^+ voltages from being present on the diode. The diode in shunt provides its own direct-current return path which is normally restricted by the coupling capacitor in the series hook-up. In either circuit, load impedances are determined primarily by video bandwidth requirements and necessarily must be relatively low values. The load capacitor must be small enough to present a reasonably high impedance to the highest video frequency of 4 megacycles and yet be large enough to hold the charge from one peak to the next of the 25- or 45-megacycle intermediate-frequency signal. The load resistor must be large enough so it will not lower the impedance of the capacitor and yet be small enough to allow the capacitor to discharge at the video frequencies. Usual values are 5 to 10 micromicrofarads capacitance and 1,500 to 5,000 ohms resistance. In the series-type circuit, the forward dynamic resistance of the diode is important since it can be large enough in comparison to the load to form a voltage divider and reduce the output voltage. Since germanium diodes have lower dynamic resistance than vacuum tubes, additional gain can be realized. However, the sharpness of resonance, *Q*, of the tuned circuit will be broadened because the lower resistance of the germanium diode over the vacuum tube will reduce the gain of the last intermediate-frequency stage. It should be restored by an increase in the load resistance.

In the shunt circuit, the back-resistance characteristic of the diode becomes the predominant characteristic. It is necessary that this back resistance be at least ten times that of the load to maintain gain. However, very high values of back resistance may sharpen the *Q* of the tuned circuit. Bandwidth then can be restored by a change of the coupling capacitor or compensating choke.

It should be realized that wider variations in the dynamic resistance of germanium diodes will be encountered than in vacuum tubes. However, detector-type germanium diodes are selected in their manufacture by test in an actual video detector circuit in order to assure uniformity of performance. Also, circuit values can be so chosen to minimize the diode variations. The improved linearity of germanium diodes at low voltages and the absence of contact potentials provide improved video output with reduced distortion in the low modulation regions. This means that the quality of the signal representing white will be improved, and, hence, the over-all picture will have a more natural rendition of the various shades of white to black.

The hum that is encountered in vacuum tubes from the heater potential can be a very important problem with series filament strings and can be eliminated with germanium diodes. Finally, the diode can be soldered directly to the intermediate-frequency coil and mounted in a shielding can to eliminate intermediate-frequency feedback in high-gain receivers. The General Electric *1N64* diode is a video detector diode selected for optimum efficiency in a detector circuit.

In many receivers, the second half of the *6AL5* was used as a d-c restorer, and in order to eliminate the tube entirely, it was necessary to provide a germanium diode with charac-



(A) (B)

Figure 2. (A) Series-type television video detector circuit; (B) shunt-type television video detector circuit

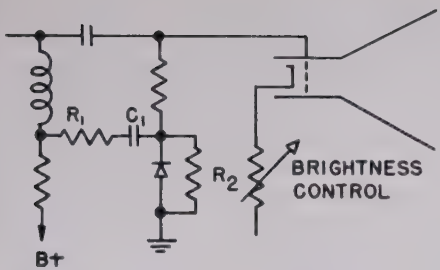


Figure 3. Receiver d-c restorer with a diode as a peak rectifier

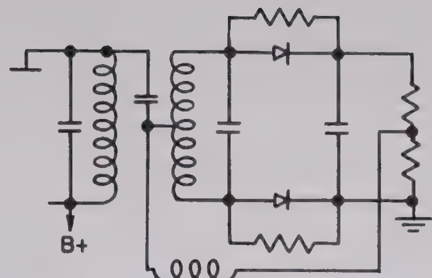


Figure 4. Foster-Seeley discriminator circuit using germanium diodes

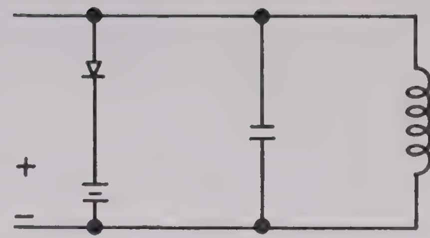


Figure 5. Diode limiter which clips off unwanted amplitude variations of the sound signal

teristics suitable for d-c restoration at a price compatible with the need. The *1N65* is such a diode.

D-C RESTORER

The function of the d-c restorer is to re-establish the correct d-c operating level of the video signal arriving at the picture tube grid to maintain a uniformity of background illumination of the picture. Capacity coupling of the video amplifiers removes the d-c level of the signal that was established at the transmitter. If a diode is installed as a peak rectifier in the grid circuit of the picture tube as illustrated in Figure 3, it will add a d-c bias dependent on the peak voltage of the synchronizing pulses and maintain the tips of the pulses at a fixed d-c level. The operating point of the picture tube is then established by the brightness control.

In the absence of the diode, the video signal on the grid would vary about an a-c axis. However, the diode will permit the capacitor C_1 to charge to a voltage proportional to the synchronizing pulse voltage adding a direct voltage to the video signal to maintain a constant reference level. A careful analysis of the operation of this circuit will show that the best performance is obtained with a diode having low forward resistance and high back resistance. Since the forward dynamic resistance of germanium diodes is lower than vacuum tubes, some improvement in performance can be realized. On the other hand, only those diodes selected for high back resistance will perform properly. The type *1N65* diode is selected to have sufficiently high back resistance for proper restorer action. It is recommended that a resistor of approximately one-half megohm be used in parallel with the diode to minimize the effect of variation of back resistance between diodes to maintain uniform performance between receivers.

The audio circuit of a television receiver is similar to a frequency-modulated receiver. Detection of the frequency-modulated intermediate-frequency signal is accomplished by a discriminator circuit or a ratio-detector circuit. Both types of circuits employ two diodes and require balanced conditions. The most common type of discriminator circuit, the Foster-Seeley circuit, is shown in Figure 4. Germanium diodes have been substituted successfully in this circuit for vacuum tubes. The only precaution that was taken was to add shunting resistors to the diodes in order to maintain a fairly uniform balance between the two halves of the circuit with respect to the back resistance.

In the ratio detector, however, balance between the two halves of the circuit becomes more critical. This is true because the purpose of the ratio detector is to provide amplitude-modulated suppression as well as frequency-modulated detection, and it depends for its operation solely on the balance of the two halves of the circuit. As previously mentioned, the back resistance of diodes is not uniform and can change with temperature and voltage level. Such changes also may not be the same in two diodes. Hence, it becomes more difficult to use germanium diodes in the ratio detector. Variations of the ratio detector have been devised that minimize the detrimental effects of the finite back resistance of the germanium diodes. Such circuits can approach the operating quality of the conventional vacuum-tube circuits.

Germanium diodes are being used widely in ordinary discriminator circuits with advantage being taken of their saving in space and weight. They can be wired directly to the transformer and mounted in the shielded can and contact-potential and filament-hum problems eliminated.

Practically all television receivers use a limiter stage ahead of the discriminator even when a ratio detector is used. The function of the limiter stage is to clip off any amplitude variations of the sound intermediate-frequency signal that may be caused by noise or nonuniform intermediate-frequency amplification over the frequency band. Usually a 1- or 2-stage grid-biased limiter is used, but it may be quite expensive. Where the normal amplification of the limiter is not necessary, a biased diode can be used more inexpensively. Figure 5 illustrates this point.

The diode with a bias voltage equal to the normal signal level is placed across a tuned circuit. It will conduct only on peaks that exceed that normal level and will short-circuit noise peaks. Harmonic distortion caused by such clipping can be minimized by using two diodes to clip both the positive and negative peaks. The bias also can be from a resistance-capacitance circuit of such value that it is automatically adjusted to the signal level.

Germanium diodes also can be used in the many varied types of synchronization separating circuits. Individual circuits would have to be analyzed, however, to determine the best grade of diode to use in these applications.

ULTRAHIGH-FREQUENCY MIXERS

Today one of the foremost problems of television engineers is the design of converters for the new ultrahigh-frequency channels. With television signals being transmitted on frequencies ranging up to 1,000 megacycles, the

conversion of these frequencies to lower frequencies presents many new design problems. The problems themselves are not new because they were met during the war; however, the cost of a home receiver must necessarily reflect new thinking in the design.

To transform the ultrahigh frequencies to lower frequencies which are more easily amplified requires a converter or mixer which will combine the received signal with a signal of an oscillator so that the difference of the two frequencies is obtained. The chief requirements of the mixer are that it will mix the received and local oscillator signals to produce a sufficiently strong output for weak signals and will not introduce distortion or noise into the signal.

One of the most widely used devices for mixers has been silicon crystals. Recently germanium crystals were introduced which will perform well at high frequencies; they have several outstanding advantages over the silicon crystal. They are the same physical size as the standard diodes except that there are small pins in each end for clip-in use rather than pigtail leads.

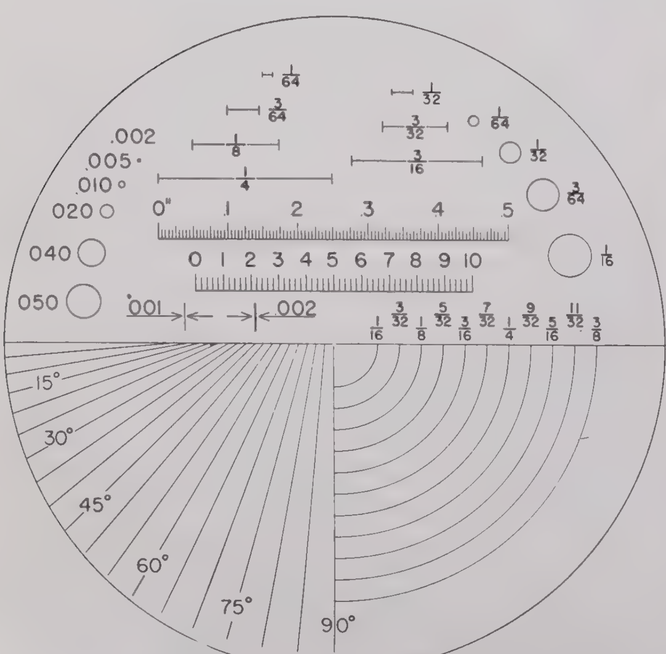
Germanium mixers are more rugged than silicon crystals, and they are capable of withstanding temporary current and voltage overloads. Their current capacity is greater, and relatively strong electric fields will not destroy them. Hence, their useful life should be many times that of silicon. The outstanding feature of the germanium diode is its cost, which is considerably below that of a silicon cartridge.

The characteristics of the germanium diode can be compared to type *1N21B* silicon crystals, which are probably the best-suited type of silicon crystal for television mixer operation. Sensitivity measurements have been made using a Radio Corporation of America Model *A* converter with a Measurements Corporation Model 84 signal generator as the signal source, and a General Electric Company Model 814 television receiver as the amplifier. The local oscillator rectified current was approximately one milliampere, and channel 3 of the receiver was used for the amplifier. The sensitivity measurement was that output of the signal generator required for one volt output at the receiver second detector load. The germanium crystals exhibited sensitivities of the order of four to eight microvolts as compared to five microvolts for type-*1N21B* silicon crystals.

All types of mixers will introduce some noise into the signal. The amount of noise injected as compared to the signal level is a very important consideration. The term "noise factor" generally is used to describe quantitatively this effect. A measurement of the noise output of the test circuit described was made by noting the signal input required to double the zero signal level noise output. Typical measurements indicated 2.5 to 5.0 microvolts for the germanium as compared to 3.0 for the silicon type.

These two measurements indicate that the germanium crystals will perform similarly to the type-*1N21B* silicon crystals in respect to sensitivity and noise. Considering the cost and other advantages, it is believed that the new germanium crystal is one of the chief factors that will contribute to the successful manufacture of television ultrahigh-frequency receivers.

The Pocket Comparator—A New Optical Measuring Instrument



A new tool for the man whose job it is to inspect small objects or small parts of large objects is the Pocket Comparator, a multipurpose device which checks linear dimensions, as well as circles, angles, and radii. A triplet-design aplanatic lens in the comparator magnifies the object being measured approximately seven times, the enlarged image being checked against a finely calibrated pattern or reticle. The upper part of the reticle has lengths graduated in 1/64, 1/32, 3/64, 3/32, 1/8, 3/16, and 1/4 inch. There is also a linear rule of 1/2 inch with 0.005-inch increments and a 10-millimeter linear rule with 0.2-millimeter increments. Circles are graduated from 0.002- to 0.50-inch diameter and from 1/64- to 1/16-inch diameter. The lower half of the reticle measures angles between zero and 90 degrees in steps of five degrees and measures radii from 1/16 to 3/8 inch. The Pocket Comparator separates in the middle, permitting cleaning of the interior optical surfaces and adjustment of focal length. Transparent plastic material between lens and reticle permits entrance of light on the reticle and the part being measured. The instrument was developed and is manufactured by the Bell and Howell Company

Flywheel-Induction-Motor Drive

JOSEPH BEN URI

Many drives with fluctuating loads must be equipped with flywheels in order to reduce the size of the motor required and the load peaks taken from the supply mains. This problem has been discussed in many papers and technical books, and it is obvious that the general-purpose induction motor cannot be used for flywheel drives. High-slip motors are most suitable as energy stored in the flywheel can be made available.

Flywheel drives are usually determined by the recovery period available for the re-energizing of the flywheel and by the overloading capability of the motor.

Quite simple mathematical expressions can be developed for the time-speed characteristic for a specific induction motor equipped with a predetermined flywheel, and from this characteristic the required reloading period usually can be calculated. Such mathematical expressions also can be found for induction motors with high iron saturation.

In a typical problem, a drive is required for a press, wherein the die form is known. It is desired to obtain 15 stampings per minute, but a time loss of approximately ten per cent must be taken into account so that the total time for one stamping will be approximately 3.6 seconds. Assuming that one-third of this time is required for the stamping period and the run-out period after recovery must be taken as one-sixth to one-fifth of the total time, 45 to 50 per cent is left for the recovery period, that is 1.6 seconds.

Two new quantities must be introduced, the relative slip for no-load $\sigma_o = s_o/s_m$ and the relative slip for peak load $\sigma_p = s_p/s_m$, wherein s_o stands for the slip at no-load, taking into consideration the motor losses and friction of the flywheel drive, s_p stands for the slip at peak load which is usually 1.5 of the rated load value, and s_m stands for the slip for breakdown torque.

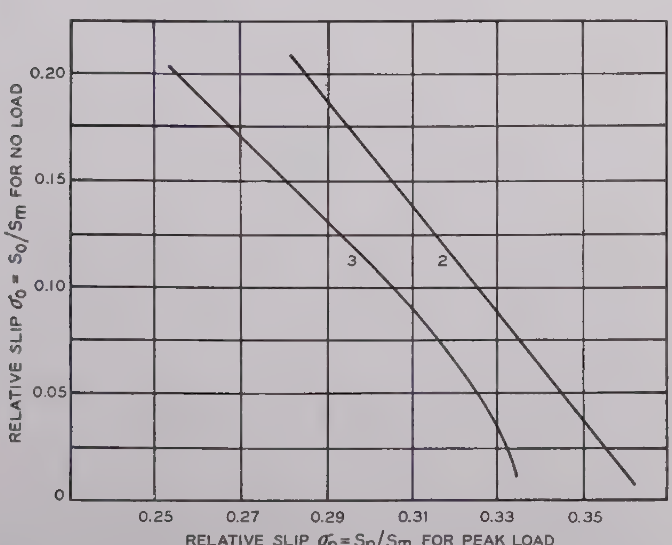


Figure 1. Optimum conditions for average heating equal to heating at rated load

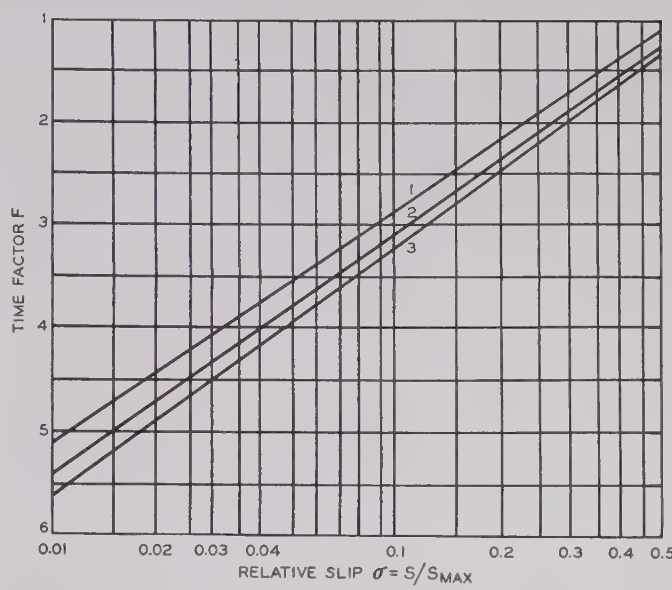


Figure 2. Chart for determination of flywheel constant of the induction motor

1—B=0, 2—B=0.3, 3—B=0.5

Another factor, the iron saturation, must be taken into consideration. For this purpose the current vector diagram must be known for load conditions of the motor in question. The saturation of the induction motor is taken as a function of $B = 2/(R_1/X + \sin\alpha)$ where R_1 represents the primary resistance, X the total reactance at rated load conditions, and α the shifting angle. The value of this saturation factor will be $B = 0.5$ for highly saturated motors and smaller for lower saturation effect.

The relative slip at no-load will be usually known, and its value will be from 0.01 to 0.03 although it may go as high as 0.10. Consider an induction motor with low motor losses. The relative slip for no-load condition is 0.012, and from Figure 1 for a certain iron saturation ($B = 0.5$, curve *3*), the relative slip for peak load is 0.34.

From Figure 2, we obtain for a variation of the relative slip from 0.012 to 0.34 a variation of the time factor $\Delta F = 3.6$. The torque, P_a, of the motor in synchronous watts can now be determined. It is $P_a = (1/2)[(s_m K)/(1+\sin\alpha)] \times (\Delta F/\Delta t)$ wherein $K = (1/2)(n_0^2/746g)(\pi/30)^2 GK^2$.

In this case a flywheel with the constant, $GR^2 = 55$ pounds-feet squared was chosen, and a 4-horsepower motor (8 poles—$n_o = 750$ rpm at 50 cycles) with a slip for breakdown torque $s_m = 0.38$ was found to be the most suitable.

Digest of paper **49-236**, "Flywheel-Induction-Motor Drive," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Not scheduled for publication in AIEE *Transactions*.

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Stability of Tandem Regulators

J. P. KINZER

IN THE *L-1* Carrier System, a pilot frequency of 2,064 kc is supplied at the transmitting terminal. Somewhat more than half the repeater stations are equipped with pilot regulators, which operate on their associated amplifiers to maintain a constant level of pilot at the amplifier outputs. By this means, variations in the loss of the coaxial cable (caused by temperature changes, for example) are compensated, and the over-all transmission maintained constant. At stations not having pilot regulators, manual gain controls are supplied; these are readjusted occasionally.

In a transcontinental coaxial circuit, there may be more than 200 regulated amplifiers in tandem. Under this circumstance there arises a problem of over-all dynamic stability, even though individual regulated amplifiers may be entirely stable. The instability manifests itself as a continuous irregular variation in transmission of moderate amplitude, termed "normal jitter," with occasional large excursions or "hits" of perhaps several decibels.

Any variation, or amplitude modulation of the pilot level, is usually spoken of as the envelope. If the pilot-frequency amplitude modulation is sinusoidal, one speaks of the envelope frequency. If the envelope frequency is relatively high, say more than 100 cycles per second, the regulator is ineffective because of thermal lag in a thermistor in the feed-back path of the line amplifier, and the pilot variation is passed through the amplifier-regulator combination without change of amplitude or phase. On the other hand, at very low frequency the thermistor is able to follow the variation, and the latter suffers a loss going through the amplifier-regulator combination. In the *L-1* system, this loss is 20 to 30 decibels at direct current. The combination therefore has an envelope transmission frequency characteristic.

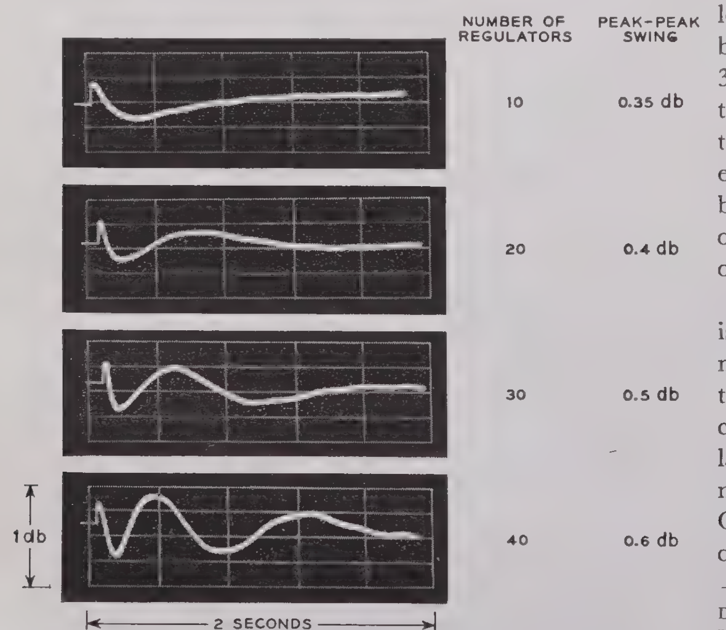

Figure 1. Transient response to 0.2-decibel step-up of loops with 10, 20, 30, and 40 regulators

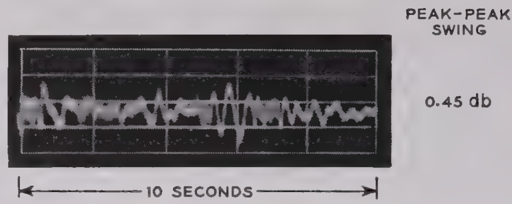

Figure 2. Normal jitter on loop with 86 regulators

The envelope transmission characteristic can be measured directly or it can be calculated from measurements on the feed-back loop of the combination. This "backward-acting" amplifier-regulator combination is a feed-back circuit with a rather well-defined feed-back loop, and general principles of feed-back amplifier design apply. The two methods of determining the envelope transmission characteristic agree well, and it is found that there is actually an envelope gain of about 0.3 decibel at 2.5 cycles per second. This adds directly for tandem regulators, so that 130 regulators would have an over-all envelope gain of some 40 decibels.

Input disturbances likely to occur in service are sudden changes, called "hits," caused, for example, by bridging a high-impedance transmission measuring set across the line to make a maintenance measurement. Figure 1 shows a typical transient produced by 0.2-decibel step-up in pilot level. The circuits were so arranged that the pilot could be observed simultaneously after passing through 10, 20, 30, and 40 regulators. As the number of regulators in tandem, and hence the over-all envelope gain, increases, the magnitude of the transient increases. When the envelope gain is large, the magnitude of the transient may be much greater than the initial disturbance. The ratio of the peak-to-peak magnitude of the transient to the size of the original step is called the magnification.

The "normal jitter" (see Figure 2) previously mentioned is believed to be the end result of the summation of a large number of transients caused by tiny disturbances all along the system whose major source is power supply fluctuation, changing the operating points of vacuum tubes in regulators and amplifiers. Normal jitter is very erratic in nature and its magnitude varies greatly from time to time. On a system with 40 decibels envelope gain, it is of the order of one-half decibel peak-to-peak.

Digest of paper **49-247**, "Stability of Tandem Regulators in the L-1 Carrier System," recommended by the AIEE Communication Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Protective Covering for Lead-Sheath Power Cables

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Last spring, the Sheaths and Coverings Subcommittee of the Insulated Conductors Committee mailed questionnaires to representative cable users and manufacturers in order to determine their views on the use of protective jackets with lead-sheath cable. Most of those responding recommend neoprene hose and plastic jackets for prevention of corrosive action, and some believe that these coverings may protect lead-sheath cable from mechanical damage.

THE MAJORITY of failures of impregnated-paper or varnished-cambric lead-covered power cable are due to the entrance of moisture through a break of some kind in the lead sheath. The sheath failures may be due to corrosion, electrolysis, mechanical damage, fatigue attributable to either vibration or cable movement, or high internal pressure. Corrosive action or electrolysis in some degree are fairly common to all lead-covered cables installed in ducts while damage due to mechanical failure is generally confined to those cables which are subjected to large daily variations in load. This latter type of failure has become of increasing importance with the higher loads which have been imposed on power cables during recent years.

The idea of covering the lead sheath with some material to prevent corrosive action is not new; tape and asphalt coverings have been employed for many years. With the development of new materials, reinforced neoprene hose jacket came in favor and has been widely employed. The thermoplastics open a new field and some of these, such as polyvinyl-chloride and polyethylene, have received some favor. Figure 1 shows typical protective coverings over lead sheath.

The duck tape and asphalt covering was not originally designed to offer any protection against those failures which occur due to the movement of the cable resulting from load cycles, but, as long as it retains its integrity, it probably offers as good protection as other coverings. The neoprene hose and plastic jacket, however, offers possibility of protection from this source of damage for longer periods of time, but the effects have not been thoroughly investigated.

There has been an increasing interest in the use of protective coverings during recent years, and committees are planning to introduce the subject of sheath coverings into specifications for power cable. In order to gather information which might serve as a guide to users, be of assistance to manufacturers, and helpful to those working on specifications, the AIEE Insulated Conductors Committee, through the Sheaths and Coverings Subcommittee, has circulated questionnaires to users and manufacturers of power cable. The questionnaires were designed to determine the reasons for use, extent of applications, type of construction employed, service data, and effect on cable rating of the protecting sheath. Replies were received from 34 users and eight manufacturers.

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SUMMARY OF ANSWERS TO QUESTIONNAIRES

Twenty-nine of the 34 users replying employ cable with jacket coverings to protect against corrosion. The majority of these employ protection only for special applications, but there is interest in the possibility for general use.

The users believe that the covering may be of value in increasing sheath life through mechanical reinforcement, but only six companies have made any tests and little or no data have been collected to indicate the thermal effect of protective jackets. Companies using currently recommended types of jackets have had no trouble in making cable installations or removals and indicate that they are receiving satisfactory jacket service life. Neoprene hose jacket has been most commonly used but there is some interest among the cable users in extruded thermoplastic jackets.

The possibility for reducing the lead thickness on lead-sheathed cables with protective jackets is well recognized by cable users, and many have already employed reduced thickness of sheath on jacketed cable.

All eight of the cable manufacturers are in a position to supply protective coverings on the cables which they manufacture, but not all of the manufacturers are in a position to supply all types of coverings which have been employed by users. Seven of the manufacturers favor the use of neoprene hose and one favors extruded polyethylene jackets. These preferences apply for both corrosion protection purposes as well as for mechanical reinforcement. Tests of the effect of jackets on cable life are being conducted by the majority, but the results are not yet available.

The majority of the manufacturers do not believe that field installation practices for jacketed cable should differ from current recommendations for nonjacketed leaded cable.

The manufacturers recommend jacket thicknesses of from 90 to 125 mils for usual cable diameters, increased up to 145 mils for large cables. If recommended jackets are employed, a reduction in lead sheath thickness of from 20 to $33^1/_3$ per cent of normal is suggested.

The majority of the users of jacketed cable limit its use to

special application, and replies indicate there is considerable variation in the practice of reducing lead sheath thickness. However, many users have suggested that when more experience has accumulated in the use of reduced lead thicknesses with reinforced jackets, they will consider such cable possibly for general application.

TYPES OF JACKETS

Twenty-four cable users report the current use of neoprene hose jacketed cable when sheath protection is required. Extruded neoprene, polyvinyl-chloride, and polyethylene are used by a few companies. The old duck tape and asphalt jacket has given way almost completely to the newer materials.

While seven of the eight manufacturers are still in a position to supply the duck tape and asphalt construction, it is not recommended by any of them. Six manufacturers recommend reinforced neoprene hose jacket; one recommends either the neoprene hose or extruded polyvinyl-chloride; and one recommends extruded polyethylene.

The principal reasons which some of the manufacturers have advanced for the general preference for neoprene hose construction is that it is of uniform thickness, is thermosetting, has good physical and aging properties, a good degree of moisture resistance, and provides good mechanical protection.

The manufacturer who recommends extruded polyethylene believes that "it is more waterproof, gives better reinforcement to the lead sheath, and can be applied without heating the cable for any appreciable length of time."

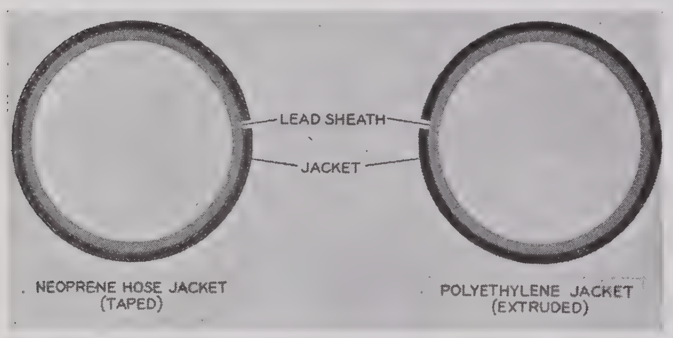

Figure 1. Typical protective coverings over lead sheath

ADHERANCE OF JACKETS TO SHEATH

It is the general practice of the users of jacketed cable to require that the jacket be cemented or naturally adhere to the lead sheath. Only two of the manufacturers do not require that the hose type of jacket be cemented to the sheath. Only one manufacturer is willing to recommend polyethylene extruded jacket without cementing.

THICKNESS OF JACKET

Ten users of cable report that the jacket thickness which they specify is proportional to cable diameters while 18 companies employ the same thickness regardless of cable size. The recommendations of the manufacturers for the jacket thicknesses vary from 80 to 145 mils. The thinner jackets are applied to small cables and the heavier walls to cables over three inches in diameter. The usual recommended thickness for medium-sized power cables ranges from 110 to 125 mils.

THICKNESS OF LEAD SHEATH

In general, the manufacturers agree that lead sheath thicknesses can be reduced when a jacket is used. The amount of reduction of sheath thickness is influenced by the type of jacket and the kind of lead or alloy employed in the sheath. There is a wide divergence of opinion concerning the allowable sheath thickness however, and individual manufacturers should be contacted for recommendations for each application.

Twelve cable users report that they make it a regular practice to reduce sheath thickness when the sheath is covered by a jacket while 18 companies use normal sheath thicknesses. Of this latter group, several are considering the use of reduced lead thickness, some with alloy sheath.

When thinner lead sheath is used, the reduction from normal ranges from 17 to $33^1/_3$ per cent. The usual reduction is near the $33^1/_3$ per cent figure. The use of reduced thicknesses usually results in sheaths thinner than those specified by the Association of Edison Illuminating Companies for impregnated-paper insulated lead-covered power cables.

OPERATING EXPERIENCE AND TESTS

It is generally recognized that one of the major causes of power cable failure is sheath damage produced by load-cycle cable movement. The application of a jacket over the lead sheath of a duct-lay power cable may appreciably affect its ability to withstand movement. Some tests which are in progress by manufacturers and users will provide data on the sheath life which may be expected with jacketed cable. The majority of cable users have collected no data, however, because the principal application of jackets has been to arrest sheath corrosion.

There have been no recognized current-carrying capacity tables published for jacketed cables, and the effect of the jacket on cable rating has been the subject of some discussion. Twenty-three companies report that they have collected no data on rating while two companies report that they reduce ratings on jacketed cables. Seven companies feel that the load ratings of jacketed cables should be the same as nonjacketed lead-sheathed cable, and one cable user reports that the rating of jacketed cable should be slightly higher.

One cable manufacturer is in the process of making tests bearing on load rating, and several manufacturers are making aging tests on the common jacket materials in order to determine the effect of cable oil, asphalt, water, and operating temperature.

Cable user's operating experience on neoprene hose and extruded thermoplastic jackets is excellent. There is a wide variation in the experience with duck tape and asphalt jacket; some companies have had only a few months life, while others have had satisfactory protection more than 15 years. However, most companies have abandoned the

use of duck tape and asphalt and are using neoprene hose or extruded thermoplastic jackets.

INSTALLATION PRACTICES

The installation of jacketed cable does not present any unusual problems. The usual number of layers of cable are placed on shipping reels whether it is jacketed or nonjacketed. The recommended bending radius is not reduced by the addition of a jacket and the installation temperature limits are unchanged.

While grease or grease-like pulling materials are used almost exclusively with nonjacketed lead-sheathed cable, these materials are not recommended for use on cables with jackets. The preferred and recommended pulling lubricants are soap, soapstone, or talc, while water and graphite is used by several companies.

Eight companies have reported difficulties with the removal of jacketed cable. In all cases of difficulty, the jacket contained either asphalt or impregnated jute. No difficulty has been reported with neoprene hose or extruded thermoplastic jackets.

Where cable is used with a jacket over the sheath, the jacket must be cut off the cable for several inches beyond the wipe of the cable joint. Twenty-one companies report that they cover the sheath between the cut end of the jacket and the joint wipe. The principal reasons given for this cover are to prevent corrosion and to provide mechanical protection or arc protection.

While the information gathered to date is not conclusive as to type of jacket or its effect on cable life, it summarizes current practices and indicates trends. The Sheaths and Coverings Subcommittee appreciates the thoroughness with which the questionnaires have been filled out and is most anxious to obtain additional data on life and thermal rating of jacketed cable as it becomes available.

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Testing Steam Turbine Generator Governors Under System Load Conditions

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A need for a method of determining the characteristics of governors of steam turbine generators has been evident for some time. This article presents the results of a study made to develop a system of obtaining the necessary data quickly and efficiently.

STEAM TURBINE governors must be tested to determine performance of a governor with respect to purchase specifications, to determine the necessity for and the results of maintenance work on the governor, and to determine the optimum settings of the governor through a knowledge of the governor characteristics and system requirements in order that each unit will perform most satisfactorily considering its size, heat rate, location on the system, and local plant steam generating conditions. If the need is only for determining conformance to specifications, elaborate equipment can be used, but to be used effectively in the maintenance and operation of the governor the equipment should be simple to operate and provide the necessary data quickly.

Test equipment needed to determine the incremental regulation, dead band, and stability of a governor connected to a large power system has been developed which has no mechanical inertia or lost motion and requires only connections to the potential and current metering circuits of the generator. The values obtained show the corresponding load change on the generator for any change in frequency. It is believed that these are the values which are most desired and are obtained directly under actual operating conditions of the unit without resort to assumptions as to the relationship between inlet valve movement and generator output. Some difficulties have been encoun-

Full text of paper **49-290,** "Determining Incremental Regulation and Dead Band of Governors on Steam Turbine Generators Under System Load Conditions," recommended by the AIEE Committee on Power Generation and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949. This is the report of an investigation sponsored by the Utilities Research Commission, Chicago, Ill.

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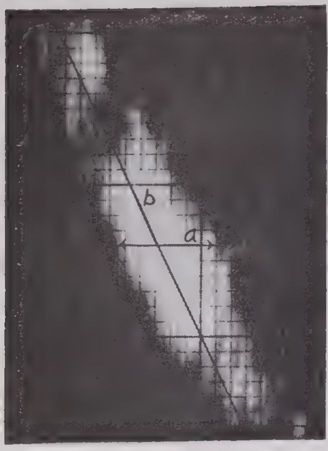

Figure 1. Kilowatts change versus frequency change

Kilowatt change (vertical scale) is 159 kw per division and frequency change (horizontal scale) is 0.005 cycle per division

tered and these are discussed with the hope that the work so far completed may be of interest to others and may stimulate thought towards a more simplified system for determining governor performance.

The information necessary to evaluate the performance of a governor is the incremental regulation, dead band, and stability at all load points. The average steady-state speed regulation is only important in estimating the performance of the machine upon being disconnected from the system,

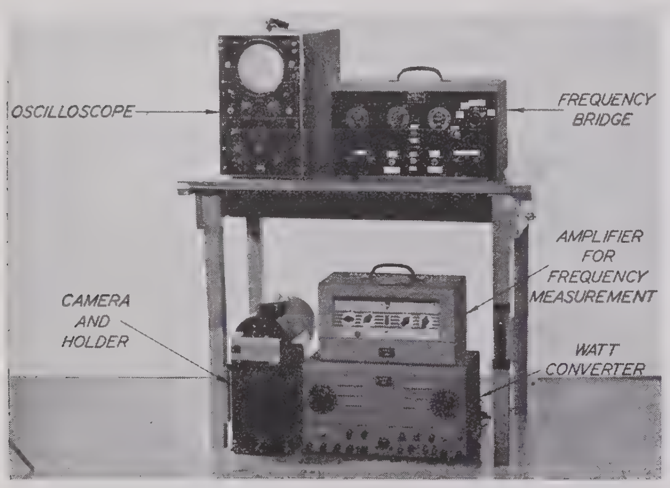

Figure 2. Apparatus to determine kilowatt change versus frequency change

since seldom is a turbine subject to frequency changes in the order of four or five per cent while connected to a large power system. However, each machine is being influenced constantly by small frequency changes in the order of 0.1 per cent and frequently 0.3 per cent. The response of the governor to these changes determines to a large extent the steadiness of the frequency, the division of a fluctuating load between the generators on the system, and the tendency for excessive changes in steam demand on the boiler room.

To maintain tie-line loads at some predetermined value and to keep a constant integration of frequency for control of clocks, most large power systems have installed remote automatic control on a number of turbines. A knowledge of the performance of a governor, therefore, is useful in determining which machines can best be used for load control. It can be seen, for instance, that if the remote load control calls for an increase of load at the moment the frequency is influencing the governor to reduce the load there will be a conflict between the sensitive governors on machines with load control and machines without load control. An understanding of these factors coupled with a knowledge of governor characteristics should assist in obtaining optimum performance of all machines on the system.

METHOD OF TESTING

A method of testing is desired that can be applied simply and does not require special attachments to the turbine. Around this principle a method was designed using a sensitive frequency bridge and a sensitive watt-converter connected into the current and potential metering circuits of the machine in such a manner that changes in both frequency and kilowatt output are converted into electrical quantities and these quantities appropriately indicated or recorded. These quantities are applied to an oscilloscope with a long persistence screen and the oscilloscope beam deflected horizontally with changes in frequency and deflected vertically with changes in kilowatts. The long persistence screen permits the pattern of the light beam to be observed for approximately 30 seconds. In this time a rotatable grid is adjusted to the slope of the figure and the degree of inclination read on a dial. If it is desired to obtain a record of the figure, a camera is placed in front of the oscilloscope. This gives a record of the type shown in Figure 1. The slope of line *b* is the incremental regulation. The line *a* is an index of the dead band. These readings are repeated at any desired interval of load and the results are plotted.

DESCRIPTION OF EQUIPMENT

The equipment used is shown in Figure 2. The standard cathode-ray oscilloscope with a long persistence screen comprises the heart of the system, and with the aid of the camera, gives a graphic record of the test data. The principle used to obtain these data by means of the oscilloscope is to apply an amplified direct voltage to the deflecting plates of the cathode-ray tube in such a manner that one set of deflecting plates will cause a horizontal deflection of the electron beam for changes in frequency and the other

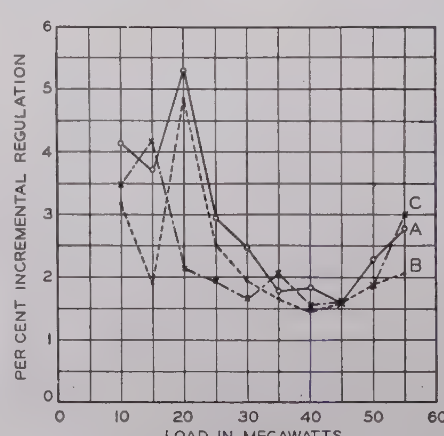

Figure 3. Comparison of three methods of obtaining incremental regulation: curve A—incremental regulation from deadband test; curve B—incremental regulation from AIEE specification test; curve C—incremental regulation determined by recording valve movement instead of kilowatt change

two deflecting plates will cause a vertical deflection of the electron beam for changes in kilowatt output. This principle is comparable to two mechanical forces displaced by 90 degrees.

The resulting movement or deflection of the electron beam is, therefore, a combination of the two electrical forces acting upon the two sets of deflecting plates of the cathode-ray tube. The instrument thus becomes an *X-Y* recorder and the diagram thus obtained consists of a multiplicity of diagrams superimposed on a common axis and it usually resembles a parallelogram.

The amplifier, watt-converter, and bridge circuit are the means by which the various factors, such as frequency change and kilowatt output, are translated into proportional electrical quantities to be applied to the cathode-ray oscilloscope. The equipment and the method of operation is further described in Appendix I.

The AIEE Recommended Specifications for Governing of Prime Movers Intended to Drive Electric Generators Rated 500 Kw and Up[1] defines incremental regulation in terms of kilowatt change with respect to speed change, or frequency change. These same specifications define dead band in terms of the speed change or frequency change over which there is no change in the position of the inlet steam valve, see Appendix II. Changes in the position of the steam valve are reflected in changes in the kilowatt output at some time interval later due to the inertia of the machine itself and the time it takes for the turbine to translate the changed steam flow into a changed power flow. Therefore, the method of determining dead band from the kilowatt output of the machine rather than from the valve movement does not conform to the AIEE specifications, but does give an index of the performance of the machine on the system under actual load conditions. Furthermore, it recognizes such factors as the inertia of the machine which may be useful in determining the response wanted or expected on a given machine. To illustrate, a machine that has a large dead band as determined by this method of testing may not be a good machine upon which to apply load control.

RESULTS OF INCREMENTAL REGULATION TESTS

Curve *A*, Figure 3, shows the results of a test for incremental regulation on a 65,000-kw reheat turbine with one overload valve.

In order to compare this method of testing with other methods of testing, arrangements were made with one of the manufacturers to conduct a test on the unit. This manufacturer's method, it is believed, determines incremental regulation in accordance with the AIEE specifications, but the equipment does not readily lend itself to quick determinations in the field. The incremental regulation obtained according to this manufacturer's procedure is shown as curve *B*, Figure 3. Another method of testing for incremental regulation was tried in which valve movement instead of kilowatt change was recorded on the vertical axis, and the kilowatts represented by this change in the valve movement were calculated, using the inlet valve characteristics curve, Figure 4. Curve *C*, Figure 3, represents incremental regulation as determined by this method on the same unit. It will be seen that the three methods of test give reasonably close agreement. The method which is used in making these calculations is shown in Appendix II.

Figure 5. Valve movement versus frequency change

Valve movement (vertical scale) is 0.0075 inch per division and frequency change (horizontal scale) is 0.005 cycle per division

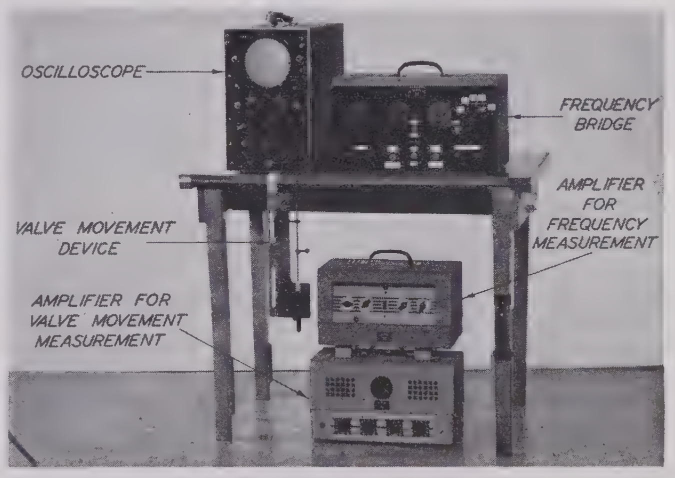

Figure 6. Apparatus for determination of valve movement versus frequency change

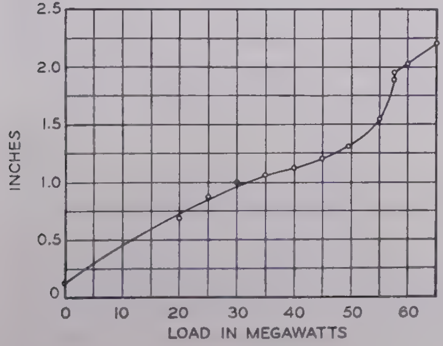

Figure 4. Inlet valve characteristics used in calculation of curve C, Figure 3

DEAD BAND DETERMINATION

The dead band as determined by frequency change versus kilowatt change is not true dead band as defined in the afore-mentioned AIEE specifications. These specifications define dead band in terms of valve movement and frequency change.

In order to study true dead band, a device as illustrated in Figure 6 was designed. The frequency bridge,

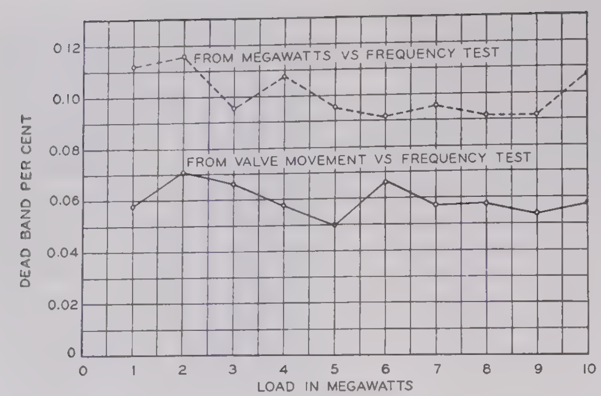

Figure 7. Results of dead band tests on 10,000-kw unit

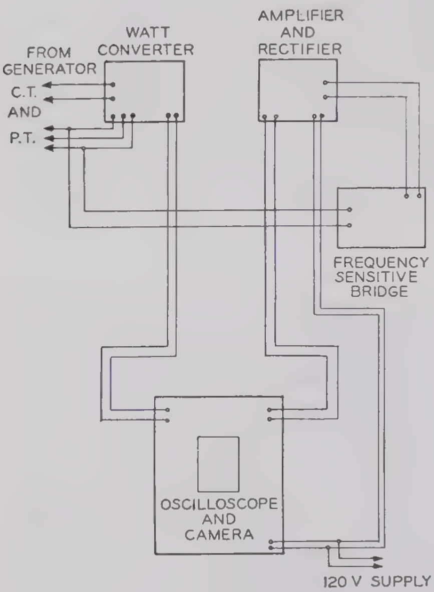

Figure 8. Block diagram of apparatus for the determination of kilowatts change versus frequency change

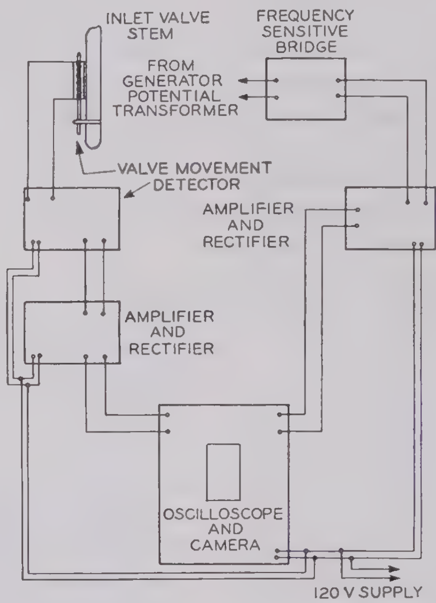

Figure 9. Block diagram of apparatus for the determination of valve movement versus frequency change

amplifier, and oscilloscope are the same as previously described. In place of the watt measuring equipment, a sensitive valve movement device was mounted on the inlet steam valve, and this movement electronically amplified so that changes in movement of the inlet valve are applied to the oscilloscope as an electrical quantity. A record obtained with this equipment is shown in Figure 5. Line *a* on Figure 5 therefore represents true dead band as interpreted from the AIEE specifications.

Figure 7 shows results of dead band obtained by these two methods. It is felt, however, that the index of dead band obtained by the kilowatt change versus frequency change method, although it cannot be used to determine conformance to purchase specifications, is a valuable index of the performance of the machine under load conditions, and when interpreted as such, and not as true dead band, has considerable value. While some of the tests show almost identical results by the two methods, many of the tests show the differences as indicated in Figure 7. The percentage dead band obtained from the power versus frequency test varies from two to four per cent higher than that obtained from the valve movement versus frequency test.

DIFFICULTIES ENCOUNTERED

One of the difficulties encountered in applying this method of testing is the presence of oscillations in the kilowatt output of the generator having a frequency of about one cycle every 0.8 second. These are quite noticeable with the sensitive test apparatus used, and also may require recognition in other problems incident to the operation of a large power system. These oscillations are independent of system frequency changes and seem to be exaggerated by fluctuating loads. Under these conditions it is difficult to obtain a reliable index of performance. In one case, after a large fluctuating load was transferred to another generator, satisfactory results could be obtained.

However, the cyclic variations under some load conditions have been sufficient to make determinations difficult and attention now is being directed towards eliminating these fluctuations from affecting the test apparatus. These cyclic changes in kilowatt output are natural phenomena in the operation of a generator on an interconnected system, and the frequency, but not the magnitude, of the fluctuations can be calculated quite readily from the constants of the system.

FUTURE WORK

The greatest need is for the development of test apparatus which will satisfactorily cancel out the oscillations. Recent tests show that this can be neutralized in the test circuit by using capacitors in the oscilloscope circuit. This gives excellent results for incremental regulation, but at the expense of the true picture of dead band.

Further work is needed to improve the technique of testing with the long persistence screen.

The equipment that is mounted on the governor valve for determining true dead band also can be moved to other parts of the governor system for tracking down lost motion.

The frequency-sensitive bridge, watt-converter, and amplifiers were assembled or purchased separately and temporary connections used. A more compact and permanently wired instrument is to be designed.

Appendix I. Methods of Tests

To obtain the "power output (kilowatts) versus frequency" values, the watt-sensitive or watt-converter device is connected directly into the current and potential metering circuits of the generator under test and the frequency-sensitive bridge device or circuit is connected

to the generator potential circuit. The watt-converter converts kilowatt output change directly to a proportional d-c voltage change and the inherent characteristic of the converter circuit supplies sufficient amplification so that the d-c output voltage can be applied directly to the cathode-ray oscilloscope. The frequency bridge is detuned to provide a polarizing effect so as to differentiate between increasing and decreasing frequency changes. The voltage output thus obtained from the bridge is a very small alternating voltage which is in turn amplified, rectified, and applied to the cathode-ray oscilloscope. Thus, the two corresponding forces proportional to kilowatt change and frequency change are applied to the cathode-ray deflecting plates, and the resulting diagram is observed or photographed to obtain a measure of the machine performance.

The "valve movement versus frequency" test, which was mentioned in connection with "check tests" shown in Figure 3, is obtained in a similar manner, except that the watt-converter is replaced by a valve-movement detector. A variable inductance, comprising one leg of an inductive bridge circuit, is coupled mechanically to the main inlet valve or power piston of the turbine. This inductive bridge circuit is unbalanced in a manner somewhat similar to the detuning of the frequency bridge circuit, thereby polarizing the output voltage.

Likewise, as with the frequency bridge, the output voltage is amplified and rectified and then applied to the cathode-ray tube. The resulting diagram thus obtained is another measure of the machine performance.

The feasibility of using a cathode-ray tube having a screen with extra long persistence, and thereby eliminating the need for photographing the screen, has proved satisfactory. This eliminates the need for the camera and holder shown in Figure 2, except in cases in which a photographic record is desired.

Experience has shown that a test run of one to three minutes is sufficient to determine the slope of a common major axis required in analysis.

Figure 8 shows a block diagram of the apparatus for measuring kilowatts change versus frequency change, and the equipment is shown in Figure 2.

Figure 9 shows a block diagram of the apparatus for measuring valve movement versus frequency, and the equipment is shown in Figure 4. If it is necessary to make a photographic record, the camera and holder shown in Figure 2 also would be required.

The size of the equipment shown in Figures 2 and 4 could be reduced considerably if a redesign were made incorporating the experience gained and using parts that now are available but were not at the time of the original design. Such a redesign would probably incorporate the amplifier and frequency bridge of Figure 2 in one cabinet of about the same size and weight as the present frequency bridge.

In Figure 4, the valve-movement amplifier should be much smaller, and as mentioned before, the frequency bridge and its amplifier would be combined.

Appendix II. Incremental Regulation

1. From an unpublished AIEE paper, "Recommended Specifications for Speed Governing of Steam Turbines Intended to Drive Electric Generators Rated 500 Kw and Up," dated November 1947, it is determined that, on a 60-cycle system,

Steady-state incremental speed regulation in per cent

$$=\frac{\textit{Cycles change in speed}\times 100}{\textit{System frequency}}\div\frac{\textit{Change in power output}}{\textit{Rated output}}$$

Therefore,

$$\textit{Per cent IR}=\frac{\Delta\ \textit{cycles}\times 100}{60}\times\frac{\textit{Rated output}}{\Delta\ \textit{power output}}$$

$$=\frac{\Delta\ \textit{cycles}\times 1.67\times \textit{Rated output}}{\Delta\ \textit{power output}}$$

The slope of the line as shown in Figure 1 gives Δ *power output* expressed for convenience in terms of megawatts per 0.1 cycle. The formula, therefore, becomes

$$\textit{Per cent IR}=\frac{0.1\times 1.67\times \textit{Rated megawatts}}{\Delta\ \textit{megawatts}}=\frac{\textit{Rated megawatts}\times 0.167}{\Delta\ \textit{megawatts}}$$

Accordingly, the *per cent IR* for the test shown in Figure 1 would be

$$\frac{0.167\times 65}{6.8}=1.6\ \textit{per cent}$$

2. Also, Δ *megawatts = Valve movement in inches per* 0.1 *cycle* (from Figure 5) × *Megawatts per inch of valve movement* (from inlet valve characteristic curve, Figure 6). Valve movement per 0.1 cycle is proportional to the slope of the line as shown in Figure 5.

Therefore,

$$\textit{Per cent IR}=\frac{\textit{Rated megawatts}\times 0.167}{\Delta \textit{Valve movement}\times \textit{megawatts per inch of valve movement}}$$

Accordingly, the *per cent IR* for the test shown in Figure 5 would be

$$\frac{0.167\times 65}{0.16\times 42.6}=1.6\ \textit{per cent}$$

DEAD BAND

Dead band is the total magnitude of the sustained speed change within which there is no resulting measurable change in the position of the governor-controlled valves. Dead band is a measure of the insensitivity of the speed-governing system and is expressed in per cent of rated speed.

Therefore,

$$\textit{Per cent dead band on a 60-cycle system}=\frac{\textit{Cycles of no movement}\times 100}{60}$$

The total magnitude of sustained speed change within which there is no change in valve position is considered to be the change in frequency represented by the line (*a*) in Figure 1 which is 6.0 divisions or 6×0.005 cycles or 0.030 cycles.

Accordingly,

$$\textit{Per cent index of dead band}=\frac{0.03\times 100}{60}=0.05\ \textit{per cent}$$

Similarly, dead band can be determined from valve movement versus frequency change, as shown in Figure 5, the line (*a*) represents five divisions, or 5.0×0.005 cycles or 0.0250 cycles. Accordingly,

$$\textit{Per cent dead band}=\frac{0.0250\times 100}{60}=0.0416\ \textit{per cent}$$

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Connection and Protection of Capacitor Banks

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THE FACT that capacitors are built in units of 25 or 15 kilovars for power circuits makes possible variety of groupings of these convenient "building blocks" to form large banks. The arrangement in which the capacitor units are connected in a 3-phase bank and the type of protective arrangement used may influence the cost of the installation; these factors will certainly have an important bearing on its operation and on the operation of its associated protective devices under fault conditions.

The simple delta and y connections are used most frequently in banks up to 13.8 kv. Above that voltage the usual method is to connect groups of parallel-connected standard units in series in each phase, and connect phases in delta or y so as to operate the capacitors as near as possible to their nominal voltage rating. It is entirely acceptable to use units of different kilovars and voltage ratings in the different series-connected groups so long as the ratios of the rated kilovars of the series groups is maintained the same as the ratios of the rated voltages of the parallel-connected capacitor units in the same series groups.

For y-connected capacitor banks the insulated neutral arrangement has a number of advantages over the grounded neutral arrangement and is usually to be preferred unless the operator's practice or the type of protective arrangement used dictate otherwise.

Protective arrangements for capacitor banks basically provide protection for the circuit and not the capacitor. Functions a protective arrangement may perform are

1. Protection against rupture of the container and possible damage to adjacent equipment.
2. Protection against system outage in the event of capacitor failure.
3. Indication of failure location.
4. Protection against overvoltage.
5. Immunity to false operations.
6. Protection against overtemperature operation.
7. Limitation of kilovar loss to minimum.

No single protective device will perform all these functions, nor are all usually required for any particular bank. Protection against rupture of the capacitor container under fault conditions is an important factor for most banks because of the possibility of damage to associated equipment resulting from such a rupture. The curves indicating time-current characteristics of capacitor units are shown in Figure 1. These were obtained from extensive tests on intentionally short-circuited capacitors and may be used as a guide in selecting protective arrangements. Some of the capacitors after short-circuit tests are shown in Figure 2.

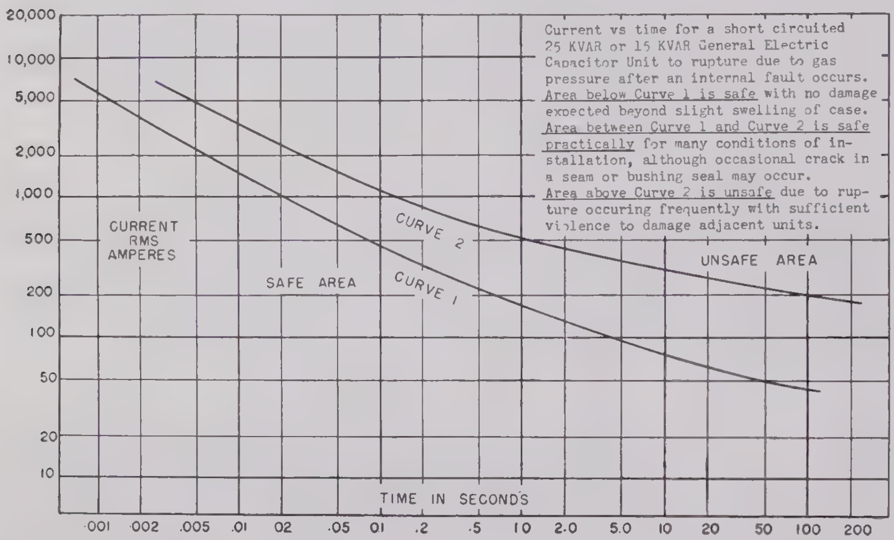

Figure 1. Current versus time for short-circuited capacitor units

Figure 2. Pyranol capacitors shown after short-circuit tests

A number of protective methods are available utilizing fuses with individual capacitor units or groups of units or relays with appropriate instrument transformers. For specific cases it may be desirable to supplement fuses or to use an alternative arrangement; however, fuses are the most common and the generally recommended means for obtaining system protection.

Digest of paper **49-254**, "Connection Arrangements and Protective Practices for Shunt Capacitor Banks," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Electric Currents in Nerve Tissue and Electric Organs

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THE function of the nervous system is that of carrying messages from one point of the body to another. Some of these messages may be received from the outside world and transmitted through relay stations to different centers, others are sent from the higher centers to the periphery and so on. The complexity of the system is strikingly demonstrated in the highest animals where it is formed by billions of units, which are the nerve cells or neurons. This communication system has frequently been compared to the telephone system, especially since electric currents are the propagating agents in both systems. Recently highly developed computing machines have been called electric brains, and there is a trend among a group of scientists to consider these electronic machines as a valuable device for obtaining information as to the functioning of the human brain. This new line of approach has been called "cybernetics" and lately has been the object of a great deal of attention.

It is possible that engineers can learn more about the nature of electricity from medical men. Factors existing in the living cell make possible minute modifications and gradations that cannot be obtained in an electrical circuit. Even in the production of electricity a study of the cell may prove helpful to engineers.*

Unfortunately, the analogy between the communication system of the animal body on the one hand and the telephone net or the electric brain is purely a formal one like that between a living muscle and a mechanical machine performing work. The basic mechanisms are so fundamentally different that there appears little hope to obtain intimate information concerning the nature of the nervous system by the study of electronic machines. As was stressed by Dr. Warren McCullough,[1] the operation of an electronic brain with ten billion units, the order of magnitude of units estimated to exist in the human brain, would require the energy of the Niagara Falls. No such energy source exists in the human brain and still it functions quite smoothly and efficiently. In the electric machines the electric currents are conducted by metal and, therefore, are identical with flow of electrons. This mechanism is absolutely excluded in the nerve cell which is a liquid system and therefore a second-degree conductor. Innumerable factors which do not exist in the case of metallic conductors influence and affect the reactions in the living cell; they make innumerable modifications and gradations possible, which account for many properties and pecularities of conduction in nerve fibers and still more of transmission across the relay stations. In spite of the fundamental difference between conduction in the nerve fiber and in the copper wire, between the human brain and the electric machine, the way in which the living cell produces electricity may be of interest to the electrical engineer looking for different types of electricity which may one day prove useful for special purposes. Therefore, some of the more recent developments and concepts concerning the electrical manifestations in nerve conduction may be outlined briefly.

MEMBRANE THEORY

Most of the modern concepts of conduction in nerve fibers are based on the so-called membrane theory, best formulated by Bernstein early in this century. Essentially this theory assumes that the nerve fiber in resting condition is surrounded by a polarized membrane which is selectively permeable for potassium ions. The concentration of these ions inside the nerve fiber is high compared with that outside. There is, therefore, a tendency for the potassium ions to pass through the membrane to the outside, but they are kept back by the negative ion for which the membrane is impervious at rest.

Thus there develops a positive charge on the outside surface of the membrane and a negative charge on the inside. When a stimulus reaches the surface, a breakdown of resistance occurs; the permeability for the negative ion is increased and this results in a local depolarization. The depolarized point of the membrane is negative to the adjacent region whereby a small electric current is generated. This current in its turn stimulates the adjacent region, leading there to a depolarization. The same process is repeated in successive parts of the nerve fiber and in this way the impulse is propagated along the axon.

Recent developments have made necessary a modification of the membrane theory in its original form. It has been shown that during the passage of the impulse there occurs not only a depolarization but an actual reverse of the charge. This result was obtained in experiments on the giant axon of squid. In this single fiber the inside diameter is large enough to make possible the introduction of an electrode into the interior of the axon. In this way a direct determination of the potential across the membrane becomes possible. The spike potential was found to be markedly greater than the potential difference in rest. In

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* Third in a series of three articles on electric eels. Others were "Electric Fishes," C. W. Coates (*E E, Jan '50, pp 47–50*), and "The Electric Discharge of the Electric Eel," M. V. Brown (*EE, Feb '50, pp 145–47*).

some cases it was nearly twice as great. It follows that the assumption of a simple depolarization cannot be maintained and that the process responsible for the generation of the flow of current is complex and is not merely an abolition of the resting potential as it might seem at first examination.

Ionic concentration gradients have been considered for a long time as the source for the electromotive force of the action currents associated with conduction. The higher concentration of potassium inside was already mentioned. The reverse is true for sodium ions. The availability of radioactive potassium and sodium made it possible to follow the ionic movements. Investigations using this radioactive material have been carried out in Cambridge, England, and in laboratories at the College of Physicians and Surgeons, Columbia University, New York. It was found that there is a continuous exchange of ions even in resting condition; the ionic equilibrium is dynamic and not static. During the passage of the impulse, however, a considerable additional amount of sodium is let into the interior, and a corresponding amount of potassium leaks out. How this movement of the two ions in opposite directions may account for the reverse of the charge is still unanswered.

No satisfactory hypothesis has been advanced so far. It is obvious, however, that events must take place in the active membrane, the site of the electrical manifestations, which make the accelerated ionic flow possible and other events must occur which restore the resting condition. Experimental evidence that such events actually take place has been obtained by observations of K.S. Cole and H. J. Curtis[2] carried out with the giant axon of squid. These investigators measured the impedance changes with alternating current of varying frequency applied across the nerve fiber. The impedance was always reduced during the passage of the impulse through the nerve fiber. Analyzing the results of their experiments, they reached the conclusion that the membrane resistance breaks down during activity from about 1,000 ohms per square centimeter to about 40 ohms per square centimeter.

CHEMICAL REACTIONS

The assumption of a process in the membrane responsible for the electrical manifestations is in agreement with all classical views. As was stated by Keith Lucas and E. D. Adrian[3] more than 30 years ago, all facts indicate that the energy for the propagation of the nerve impulse cannot be derived from the stimulus itself but must be supplied locally by a "propagated disturbance." The most likely assumption as to the nature of the "propagated disturbance" is that of a series of chemical reactions producing a change of the proteins of lipoproteins of the membrane and resulting in an increased permeability. Some kind of trigger mechanism must be responsible for the change by which the ionic concentration gradient, inactive in rest, becomes effective. The change in the membrane required for this process must be associated with an irreversible loss of energy. The reversal will require energy supply which can be conceivably derived from chemical reactions only. In logical conclusion of his views, Keith Lucas postulated that conduction in the nerve fiber must be associated with heat production, although at that time all attempts to demonstrate it had failed. In 1926, however, A. V. Hill[4] and his associates were able to demonstrate heat production associated with nerve activity, and in the same year evidence was obtained by R. W. Gerard and O. Meyerhof[5] that conduction is accompanied by extra oxygen uptake.

These investigations have established the experimental basis for the assumption that conduction is associated with chemical reactions. For the understanding of the mechanism of nerve function it is necessary to know the nature of these chemical changes generating the flow of current. The difficulty of finding this answer is easily understood if we consider the information obtained by the physical recordings of conduction. The initial heat produced per gram nerve per impulse in a frog sciatic nerve is of the order of magnitude of one to two ergs or 10^{-8} gram-calories. The chemical reactions involved in the primary event must take place within one-tenth of a millisecond or less. Reactants in a process of such a high speed, metabolized in amounts of such a small order of magnitude, cannot be measured directly so some other method of studying these phenomena had to be devised.

ENZYMES, THE CATALYSTS

Instead of following the reactants, it is entirely possible to study the catalysts which are responsible for all chemical reactions in the living cell, the enzymes. These enzymes are powerful and dynamic mechanisms and relatively stable. By studying their activity in vitro and by correlating it with events in the living cell, recorded by physical methods, much valuable information may be obtained concerning chemical mechanisms of cellular function. Such an approach was tried successfully in the case of muscular contraction and appeared to be the most promising approach to the study of the basic mechanism of conduction of impulses.

During the last 40 years a compound called acetylcholine has been associated with nerve activity, especially in view of its very powerful pharmacological properties. Studies of the enzymes associated with the formation and breakdown of this compound have revealed that acetylcholine is intimately associated with the electrical manifestations observed during activity. A great variety of facts have been accumulated supporting the assumption that the release and the removal of acetylcholine are reactions in the neuronal surface membrane essential for the generation of the electric currents propagating the impulse from one part of the tissue to another.[6]

The enzyme which has the physiological function to hydrolyze acetylcholine and hereby to inactivate the compound is called acetylcholine esterase.[7] The enzyme has several most remarkable features.[6] The reaction occurs at an extremely high rate. The so-called "turn-over number" is 20 million per minute or even higher, indicating that one molecule of ester may be hydrolyzed in three to four millionths of a second. This high speed is pertinent for any assumption correlating a chemical reaction directly with the electrical manifestations of conduction.[6] The enzyme is localized exclusively in the surface of the nerve cell where

the bioelectrical phenomena occur. This is in contrast to many other enzymes, even those required for conduction, as for instance the respiratory enzymes. The concentrations of the enzyme are adequate to account for an amount of acetylcholine which is comparable with the assumption of an essential role in conduction. Acetylcholine esterase is present in all conducting tissues throughout the whole animal kingdom.[12] It has a number of properties by which it may be easily distinguished from other esterases occurring in the organism.

All these features of acetylcholine esterase are very suggestive. They would not, however, permit the assumption of the essentiality of the enzyme for conduction. For such a postulate the enzyme activity must be correlated directly with the electrical events of conduction. This has been done in a variety of ways which will be described in the following paragraphs.

STUDY OF THE ELECTRIC EEL

For establishing a correlation between electrical phenomena and chemical reactions the availability of electric organs of certain fish was essential. There are several species which have very powerful electric organs. The species with the most powerful electric organ known is the *Electrophorus electricus*—the "electric eel"—which occurs in the Amazon River. In this fish the discharge of the electric organ amounts on the average to 500 to 600 volts. The most interesting and important aspect of these electric organs is the fact that their powerful electric discharge is identical in nature with the nerve action potential of ordinary nerves. The only distinction is the arrangement of the elements, the electric plates, in series, as in a Voltaic pile. The potential difference developed by a single element is about 0.1 volt which is the same order of magnitude as that found in ordinary nerves. In the electric organs of *Electrophorus* there are about 5,000 to 6,000 elements arranged in series, from the head to the caudal end of the organ. It is this arrangement which accounts for the powerful discharge.

An extraordinarily high concentration of acetylcholine esterase has been found in these electric tissues. One kilogram of tissue may metabolize several kilograms of acetylcholine per hour, or several milligrams in one thousandth of a second. These are significant amounts which make possible the assumption that acetylcholine is directly associated with the generation of the action potential. In this case the compound must appear and disappear in milliseconds and the only means of removing this compound so rapidly would be by enzymatic action. The high concentration of the enzyme appears particularly significant in view of the chemical composition of these organs. They contain 92 per cent water and only 2 per cent protein. A more detailed analysis between the correlation of acetylcholine esterase concentration and voltage has been carried out on the electric organ of *Electrophorus electricus*. This species is particularly favorable for such studies since a number of plates per centimeter and consequently the voltage per centimeter decreases from head to the caudal end of the organ.

The acetylcholine esterase activity decreases in the same proportion as the voltage per centimeter decreases from head to tail. If the electric potentials are recorded and compared with the enzyme activity of the same section, a close parallelism is obtained between voltage and enzyme activity. The voltage per centimeter varies not only in the same specimen but still more in specimens of different sizes. During the last war a great number of specimens of various sizes became available in connection with work on an extremely toxic substance, a powerful chemical warfare agent, the di-isopropyl fluorophosphate (DFP) which is a potent inhibitor of choline-ester splitting enzymes.

The availability of such a great number of specimens of various sizes made it possible to correlate voltage and enzyme activity over a wide range, varying from 0.5 to 22 volts per centimeter. A direct proportionality has been established between the voltage of the action potential and the concentration of acetylcholine esterase over this wide range.[8] No other enzyme tested shows any parallelism. The results support the assumption of a close relation and interdependence between these electrical and chemical processes.

ENERGY FOR THE ELECTRICAL PROCESS

The electric organ is also an unusually favorable material for the study of the chemical reactions supplying the energy for the electrical process. In view of the small energy involved in conduction, the chemical reactions in ordinary nerves are not within easy range of measurements, whereas in the electric tissue it has been possible with the methods available to correlate the electric and the chemical energy released during activity.[9,10] It is known from work of Otto Meyerhof[14] and his school on muscle that the most readily available source of energy in living cells is that released by certain energy-rich phosphorylated compounds. The two most important compounds of this type are phosphocreatine and adenosinetriphosphate. The breakdown of adenosinetriphosphate precedes that of phosphocreatine, and today it is generally assumed that the breakdown of adenosinetriphosphate may be the primary chemical reaction during muscle contraction reacting with the muscle proteins.

The phosphocreatine acts as a storehouse for energy-rich phosphate and rephosphorylates the adenosinetriphosphate if a phosphate is split off. Experiments with the electric tissue have shown that the energy release of the breakdown of phosphocreatine is adequate to account for the total electric energy released by the action potential. It was safe to assume that the breakdown of adenosinetriphosphate during nerve activity precedes that of phosphocreatine like in muscle. It appeared unlikely, however, for many reasons that the breakdown of adenosinetriphosphate is a primary reaction connected with conduction in the tissues.

The item which causes greatest difficulty among the many other obstacles in the experimentation is the time factor. There is no evidence that adenosinetriphosphate may be metabolized at the speed required for the primary event in conduction. On the basis of the available evidence it appeared more likely to assume that the release and removal of acetylcholine are the primary events con-

nected with the changes of the protein or lipoprotein in the active surface membrane.

The breakdown of the adenosinetriphosphate was assumed to be the primary recovery process, supplying the energy for the resynthesis of the acetylcoline hydrolyzed during the passage of the impulse. If this is correct, the energy of the adenosinetriphosphate should be used for the resynthesis of acetylcholine. In accordance with this postulate, a new enzyme, choline acetylase, was extracted from brain tissue which in cell-free solution synthesizes acetylcholine using the energy of adenosinetriphosphate.[11] Thus, with the aid of the electric fish, a whole chain of chemical reactions has been established and associated with the electrical manifestations. In this way the metabolism of acetylcholine has been integrated in the general metabolic cycle.

CONDUCTION INHIBITORS

One frequent method of testing the role of enzymes in cellular function is the study of the effect produced by specific inhibitors. Obviously, if conduction in nerve and muscle is dependent upon the rapid removal of acetylcholine by acetylcholine esterase, inhibitors of the enzyme should block conduction. Studies on the inhibitors of choline ester splitting enzymes have supplied conclusive evidence for the necessity of acetylcholine esterase in conduction, and these studies have shown that these two events cannot be dissociated.

It was found that eserine, a well-known inhibitor of choline ester splitting enzymes, abolishes conduction. The inhibition of the enzyme can be readily reversed and it is found that the electrical effects are equally reversible. Recently inhibitors of choline ester splitting enzymes became known which destroy the enzyme irreversibly. As mentioned before, they are powerful potential chemical warfare agents. One of these new compounds which has a potent inhibitory effect on acetylcholine esterase is the di-isopropyl fluorophosphate (DFP). The irreversible destruction of the enzyme is, however, in this case not an immediate process but requires a certain length of time during which a reversibility of the enzyme inhibition can be demonstrated in vitro.

The rate of the progressively irreversible destruction depends on several factors like concentration, temperature, and others. A most striking parallelism was found in nerves exposed to di-isopropyl fluorophosphate (DFP) between the progressive irreversible inhibition of acetylcholine esterase and the progressive irreversible abolition of conduction. The interdependence of the two processes has been shown as a function of temperature as well as a function of time. The effect of inhibitors of choline ester splitting enzymes on conduction has been demonstrated on a great variety of types of nerves: mammalian, cold-blooded, invertebrate, motor, sensory, so-called cholinergic, and adrenergic. Conduction in striated muscle, generally believed to be identical in nature with conduction in nerve fibers, is affected in the same way. The experiments with these inhibitors have demonstrated the generality of the association of acetylcholine esterase with conduction.[12] The necessity of the enzyme system in conduction appears to be well established by means of these experiments.

ELECTROGENIC ACTION OF ACETYLCHOLINE

Finally, it may be mentioned that it is possible to demonstrate the electrogenic action of acetylcholine by injecting the ester into electric tissue.[13] The injection produces potential changes, similar to the natural discharge. This observation suggests that the physiological release of acetylcholine precedes the electrical manifestations and does not occur in recovery. There is, however, a striking contrast between the natural discharge and that produced by acetylcholine injection. The voltage is extremely small and the duration is considerably increased. Although a quantitative evaluation is impossible, the discrepancy as to duration and strength is enormous. Any extracellular compound has to react at the site of action by diffusion which is a slow process. No such difficulty exists if the compound is released intracellularly in the active membrane, possibly at a distance of a few Angstroms of the active protein or lipoprotein.

Although the precise function of acetylcholine is still unknown, especially as to the possible way of interaction between the ester and the protein or lipoprotein of the membrane, the observations outlined show that progress has been achieved in the understanding of electric currents conducting the nerve impulses. Although this is, of course, of primary interest for physiology and medicine, it may also be valuable for those studying the ways in which nature produces electricity.

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Mobile Radio Sets on 152–174 Megacycles

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THE RAPID GROWTH of the relatively new 152–174 megacycle band has resulted in complete utilization of all available channels which were assigned alternate 60 kc by July 1949; then the Federal Communications Commission (FCC) suggested assignments every 60 kc. The problems resulting from this ruling were: the adjacent channel selectivity required; the intermodulation products caused in the land and mobile receivers by three or more transmitters operating in the same area; the design of mobile transmitters to meet the FCC requirements regarding spurious radiation; and the modulation limiter to prevent the transmitter from overmodulating.

Considerable field work was experienced under actual adjacent-channel tests with two or four channels operating simultaneously. The experience gained from the experimental work decided the following parameters for the design of this new adjacent-channel mobile equipment.

Mobile receivers.

1. Sensitivity—0.5 microvolts for 20 decibels noise quieting.
2. Adjacent channel selectivity—100 decibels attenuation at ±60 kc.
3. All spurious responses to be attenuated 85 decibels.
4. Frequency stability—0.003 per cent from −30 to +60 degrees centigrade ambient temperature.
5. Frequency range—152 to 174 megacycles.

Mobile transmitters.

1. Power output of 12 to 14 watts.
2. Modulation limiter which produces a high average modulation on sudden increase of speech energy. The limiter should prevent overmodulation and introduce no distortion or microphonics.
3. All spurious emissions to be attenuated at least 60 decibels.
4. Frequency stability—0.003 per cent from −30 to +60 degrees centigrade ambient temperature.
5. Frequency range—152 to 174 megacycles.

The land station equipment must necessarily equal or better the performance of the mobile receiver and transmitter as outlined in the foregoing.

In the design of the receiver the sensitivity requirement was met with a grounded-grid *6BH6* inexpensive tube instead of the conventional *6AK5*. The 100 decibels of attenuation at ±60 kc was obtained at 2 megacycles with conventional intermediate-frequency transformers. The radio-frequency mixer was carefully designed to attenuate all spurious responses at least 85 decibels.

The transmitter was designed with a double "pi" network for the power amplifier output circuit which attenuates all spurious responses in the band at least 85 decibels and all harmonics and subharmonics at least 60 decibels.

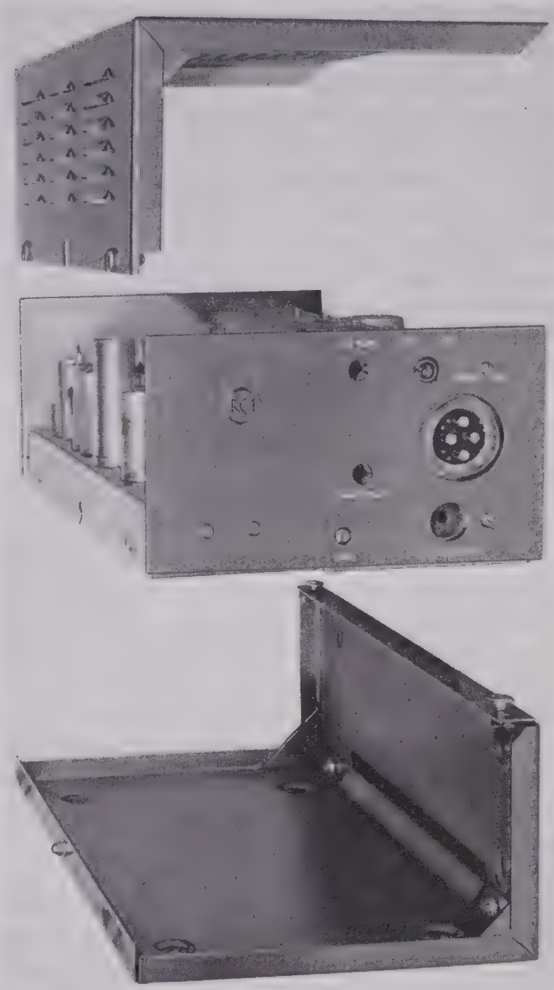

Figure 1. Case assembly for mobile equipment

The modulation limiter maintains effective control in limiting 100 per cent modulation to ±15 kc deviation over a 20 decibel change in speech energy. The design is such that no distortion or microphonics can be introduced to the modulating signal. To insure optimum performance under extreme temperature variations from −30 to +60 degrees centigrade ambient temperature the completed equipment was carefully tested for several days at 90 per cent humidity and 60 degrees centigrade. The mobile equipment was designed to operate at optimum performance while subjected to several hours of vibration in three planes with an amplitude of ±1/32 inch and a frequency variation from 5 to 55 cycles per second.

To simplify mounting and servicing a sandwich-type case, see Figure 1, was developed. This case can be mounted in two planes and the chassis can be rotated 180 degrees without changing the position of the case.

Digest of paper **49-256**, "Design of Mobile Radio Communication Equipment for Land-Mobile Services Operating on Frequencies Between 152–174 Megacycles," recommended by the AIEE Committee on Communication and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Optimum Rating of Rectifiers for Coal Mining

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THE SELECTION of a rectifier substation for the conversion of alternating current to direct current for the purpose of supplying power for cutting, loading, and hauling coal in mines is a problem to be studied from the standpoint of voltage drop, losses, economics, and maximum loads. From this, and actual field tests and data, the conclusion is reached that for average mining conditions, the optimum size rectifier substation is 300 kw.

The factors involved are maximum load, load factor, equipment rating, economical distance of transmission, and allowable voltage regulation. Load factors for mining conversion substations vary a great deal. With the rise in load factor due to mechanical mining and based on years of experience, 35 per cent load factor is believed to be a fair value. Present-day standards for rating mining conversion equipment is 50 per cent overload for two hours and 100 per cent for one minute.

Due to the highly fluctuating character of the load, poor load factor, and high short-time peaks, standards for permissible voltage drops are somewhat lower in mining than in other industries. The mining industry generally accepts a maximum voltage drop of 20 per cent. The question of how far a given amount of power can be transmitted becomes one of the economics. The cost of necessary copper to limit voltage drop to 20 per cent must be balanced against the additional cost of spacing substations at more frequent intervals.

The mining industry generally accepts as a standard base for calculation a feeder system composed of one "9-section trolley" plus one 1,000,000 circular-mil feeder and a grounded return of 60-pound rail, bonded and cross-bonded. This is for 275-volt operation. Values used in the following discussion may be approximated for 550-volt operation by increasing by four for the transmission distances while the power losses remain the same.

Calculations are based on resistance values taken from a paper submitted to the Committee on Underground Power of the American Mining Congress by F. L. Stone and published in the *Mining Congress Journal* of October 1941. The annual costs in dollars were computed on a power cost of two cents per kilowatt-hour for d-c power and the use of the curve given in Section 13, Paragraph 9 of the "Standard Handbook for Electrical Engineers" edited by A. E. Knowlton.

With the foregoing standard feeder system, allowing a 20 per cent voltage drop at 275 volts, 200 kw can be transmitted 4,525 feet with a loss of 40 kw and with an annual cost of this loss of $1,200. For 300 kw the distance is 3,040 feet, power loss is 60 kw, and annual cost of loss is $1,800. For 400 kw the distance is 2,275 feet, the loss 80 kw, and annual cost of loss $2,400, while for 500 kw the distance is 1,800 feet, the loss 100 kw, and annual cost of loss $3,000. With modern mechanized mining 300 kw is the smallest size station practical to carry the loads imposed. Loads of 400 kw and 500 kw could only be transmitted short distances. It is evident that with this feeder combination, 300 kw is the optimum size.

To transmit 400 kw the same distance as 300 kw requires an investment in feeders of $3,000 and annual losses are increased $600. This load of 400 kw may be transmitted the same distance as 300 kw with the same losses, but would require a feeder cable investment of $6,300. From a standpoint of economics 300 kw is the optimum size.

The maximum load that the substation will be required to carry is determined by a number of factors. Connected load, diversity factor, distance of the load from the station, and distance of the load from the nearest other station feeding the d-c trolley are all factors determining the maximum load on the station. Many stations are so located that the load carried by them is haulage only. Such stations will have maximum load when the "trip" is passing the station. Two 15-ton locomotives in tandem exerting maximum drawbar pull in starting a load can be handled easily by a 300-kw station. "Trips" should be so scheduled that if more than one heavy haulage locomotive or tandem locomotives are used that they are not in the section served by any one station at the same time. This should be done, not only to reduce the load on the station, but to keep down maximum demand. A 200-kw station is too small to handle any large haulage load. Therefore, for any station handling only haulage load 300 kw is the optimum size.

From many cases studied in the field, four were chosen which seemed to be representative. In three of these cases, 400-kw rectifiers were in use and in the other a 300-kw rectifier was used. In only one case was the 400-kw rectifier needed and in this case, distance of transmission was 6,900 feet, voltage drops much greater than 20 per cent, and feeder costs and losses were unusually high. In this case it would have been much more economical to have used two 300-kw rectifiers. In the case of the 300-kw rectifier, it was serving four complete mechanical sections and haulage with a total connected load of 1,421.5 horsepower. It is shown from these cases, that for practical purposes and from a standpoint of maximum load, 300 kw is the optimum size rectifier for coal mining service.

In some cases where the load is somewhat in excess of the one minute capacity of a 300-kw station a special regulator can be supplied for the rectifier so that when a predetermined load is reached the voltage will drop allowing part of the load to be transferred to other station or stations.

Digest of paper **49-255**, "Selection of Optimum Rating of Mercury Arc Rectifiers for Coal Mining Service," recommended by the AIEE Committees on Electronic Power Converters and Mining and Metal Industry and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949. Not scheduled for publication in AIEE *Transactions*.

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A New Electronic Telegraph Regenerative Repeater

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An all-electronic device has been developed for removing distortion from start–stop teletypewriter signals. It provides low output distortion, high tolerance to input distortion, hit reduction, transmission of steady-space break signals, and regeneration of one element length of stop time. This repeater is operated on office battery power and enables the attendant to change code and speed quickly as well as to do routine maintenance with one adjustment.

THE GROWING use of teletypewriter service has brought about an increasing need for regeneration. Operating speeds have tended to become higher; more multibranched long-haul circuits are being used, and it has become desirable to allow greater latitude in the maintenance of receivers and other apparatus. These factors cause an increase of signal distortion along the transmission path and a loss of tolerance to distortion at the receiving end of the path. Where the signal distortion is excessive, a regenerative repeater (or even several regenerative repeaters) connected along the circuit may be the best economic answer, and is frequently the only answer to the problem.

Relative to the age of telegraphy itself, the regenerative repeater is a new device. Its use became possible only after the adoption of the printing telegraphy system, and in its first form it utilized the mechanical distributor which was also employed in sending and receiving apparatus. This repeater[1] satisfactorily achieved its major objective; but with rotating brushes regular and frequent maintenance is essential to successful operation. To avoid the disadvantages of brush and commutator maintenance, a repeater was developed which used cam-driven contacts for the essential timing of the output signals.[2] The cam-type repeater reduced maintenance time to two or three man-hours per month (per one-way repeater), and it has been widely used since 1936.

More recently, at least ten regenerative repeaters[3,4,5] using electronics in some form have been designed, here and abroad. In each of these, it is the timing circuits which set the style of the complete repeater. The nonmechanical timing methods include resistance-capacitance phase shift oscillators, inductance-capacitance oscillators, free-running and one-shot multivibrators, gas tube relaxation oscillators, and inductance-capacitance delay networks. All of these methods have been used, and each of them has certain specific advantages, and possibly disadvantages, of economy, stability, size, weight, and maintenance.

The repeater here described is an all-electronic device known as the *143A* Regenerative Repeater. It was designed specifically to meet the requirements imposed by Bell System teletypewriter service. A number of these repeaters have shown satisfactory performance in commercial service for over a year.

In any semisynchronous or start–stop regenerative repeater, two timing functions are required; they are character timing and element timing. Character timing synchronizes the receiver by responding to only the initial transition of each coded character. Element timing determines the instant of occurrence for the transitions of the code-selecting elements in the reformed output signals.

PRINCIPAL CIRCUITS

A block diagram of the *143A* Regenerative Repeater is shown in Figure 1. Element timing in this repeater is generated by a start-stop inductance-capacitance oscillator whose frequency is such that one cycle of sine wave is produced for each element of the code.

The oscillator is started by the input-signal start element. Impulses derived from the sine wave are then applied to the character timing circuit and to the transmission circuit where the signals are regenerated.

Character timing is accomplished by a 3-stage binary-type counting circuit which counts the number of cycles of the oscillation and stops the oscillator when the proper number of cycles has been generated.

The output signals are reformed by a modulating circuit and a flip-flop circuit. The modulating circuit combines voltages from the input signals with impulses from the element timing circuit, and applies impulses selectively to either the left or right grid of the flip-flop circuit which then will follow the sense of the input signals—minus their distortion.

CIRCUIT DESCRIPTION

The details of circuit operation are illustrated by the functional schematic, Figure 2. The general layout is the same as that of the block diagram. Secondary apparatus such as grid-bias resistors, by-pass capacitors, and vacuum-tube heaters are not shown. The voltage wave shapes are approximately those which would be viewed on an oscilloscope with the letters *A* to *H* indicating points of identical time. This drawing is perhaps best understood

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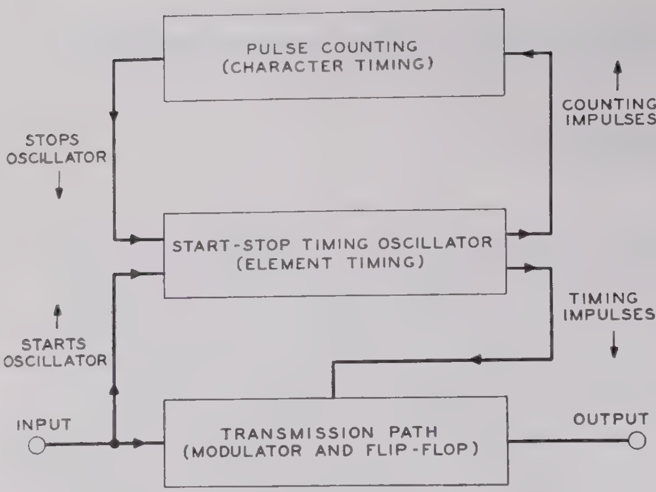


Figure 1. Block diagram of principal circuits

by studying the various parts of circuit operation in the following sequence:

1. *Oscillator Control.* This is a 2-input circuit which causes the oscillator to start conditionally when the input becomes spacing and holds the oscillator in the running condition after the counting circuits are started.

2. *Inductance-Capacitance Oscillator.* To avoid signal distortion, it is necessary that the oscillator start and stop without transients. Transientless starting is effected by applying a direct current through the inductance and approximately zero voltage across the capacitor during the idle period between characters. When the source of this holding current is cut off upon receipt of a start signal, the current in the inductance must flow into the tuning capacitor. The capacitor then charges sinusoidally. The direct current becomes the peak value of the alternating current, and the peak voltage is initially $E_m = I\sqrt{L/C}$ (volts, amperes, henrys, and farads).

The voltage peaks of subsequent cycles are kept equal to the peak value of the first cycle by adjusting the feed-back energy just to balance the resonant circuit losses. Stopping transients are avoided by stopping at the exact end of a cycle, at which time the alternating current is just equal to, and in the same direction as, the reapplied direct current.

3. *Square-Wave Generator.* The connection to the modulator circuit is used to supply positive impulses for the selecting or input-sampling function. These impulses (derived through series capacitors) are centered with respect to an undistorted input signal element and consequently allow a maximum displacement of either end of the element with respect to the start transition.

4. *Modulators.* The lower triode is biased so that only the positive impulses which occur during marking elements will be amplified. The upper triode is biased similarly, but it receives inverted input signals so that only the positive impulses which occur during spacing elements will be amplified.

5. *Output Flip-Flop.* By its holding action, this circuit converts the transient information contained in the selecting impulses into "d-c" square waves bearing the information of the input signals and the timing of the locally-generated impulses.

6. *Cathode Follower.* This is a power output stage.

7. *Initial Counting Impulse.* The same modulator impulse which samples the input start element is also used to generate the first counting impulse. The modulator pulse (dotted line) is amplified by the count recognizer circuit and applied to the first counter (via dotted line) which is caused to flip.

8. *Counting Circuits.* When the left triode of a counter circuit flips to the conducting (negative plate) condition, the impulse thus generated flips the succeeding counter in either direction. In the idle condition the three left triodes have positive plates, and therefore the action of the initial counting impulse is to flip all the counters in rapid succession. Seven subsequent negative impulses from the square-wave generator are required before the idle condition of the three counters is again attained.

9. *Count Recognizer.* After transmitting the initial counting impulse, this tube remains cut off as long as one or more of the count voltages is negative. When the three count voltages are again positive (idle condition, time *H*) the count output voltage applied to the oscillator control circuit will act to stop the oscillator, provided the input signal is marking at the same time. If the input is not marking (as in the case of a stop signal shortened to less than the length of a unit element) the oscillator will not be stopped but will continue for another 7-cycle count.

10. *Marking Ensuring Circuit.* This tube provides a conductive link between input and output during the idle condition. It therefore prevents a spacing output signal in the presence of a steady marking input signal, as might otherwise occur, for example, when power is first applied to the repeater.

ADVANTAGES

This repeater affords the following advantages in line with the general requirements.

Low Maintenance. The general rise in maintenance cost per man-hour is well known. This repeater is designed to require negligible routine maintenance for itself and to permit a reduction in maintenance requirements for all other transmission apparatus, including teletypewriters, in circuits using the repeater.

The regenerator units are usually operated 24 hours per day. Specially-designed vacuum tubes and regulated office filament battery provide a tube life measured in years, while the other apparatus represents a good compromise between reliability and first cost. The first use of these repeaters was in an installation of 40 units. Troubles of all kinds during the first year averaged one per four months per repeater and represented a maintenance-time improvement of almost six to one over that of their counterpart in mechanical regenerative repeaters. Analysis of the trouble reports indicates that no failures have resulted from circuit design inadequacies. Most recurrent failures have been caused by capacitors whose temperature rating was exceeded by the high ambient temperatures, which resulted when the maximum number of regenerator units were mounted on a single bay. These troubles have since been eliminated (at a small increase in first cost) by changing to capacitors of higher temperature rating.

Only one routine adjustment is necessary to take care of vacuum tube aging; that is, adjustment of the oscillator stop current. All other functions, including tuning, are independent of tube characteristics during the life of the tube. Tuning and oscillator feedback are factory adjustments.

Compactness. Because of the increased number of regenerated telegraph circuits, required floor space and weight of the repeater are important. The circuit is fully electronic and uses miniature tubes, pigtail resistors, and so forth. This, together with the simple timing device, enables 34 regenerator units to be accommodated in a standard $11^1/_2$-foot by 19-inch relay rack bay. Each unit weighs 13 pounds. A single unit is shown in Figure 3.

Tolerance to Distortion. The width of an element sampling impulse is less than one per cent of the width of a signal element. (All percentages are in terms of a whole element.) The impulses are timed to be in the exact center of an undistorted incoming signal element; accordingly, any transition of the input signals may be displaced up to $49^1/_2$ per cent without causing an error. Tuning inaccuracies reduce this tolerance, but experience indicates that 45 per cent is a reliable minimum under field conditions.

Stability. Over a range of 55 degrees Fahrenheit, temperature compensation of the tuning capacity keeps the maximum output distortion under two per cent in most cases (four per cent, in one case out of six). Over a period of one or two years an additional drift of not more than three per cent distortion, or one-half per cent frequency error, caused by aging of the coil and capacitor, is anticipated. The aging error can be removed at any time by an adjustment of the capacity, and the temperature error can be removed by allowing a warm-up time before adjustment. This degree of stability is obtained without resort to expensive tuning components.

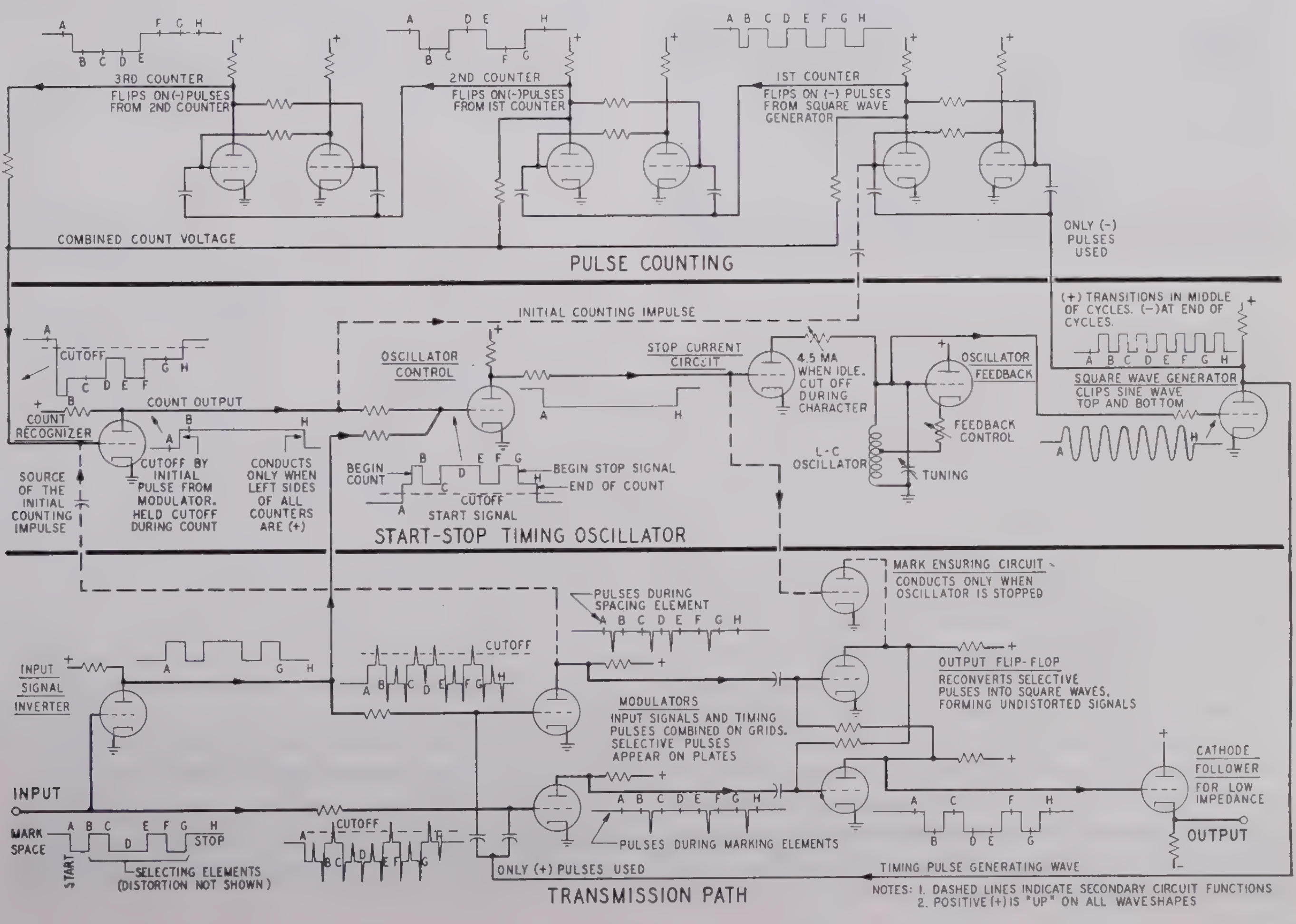
Use of Office Battery Power. Power supply of +130, −130, and −24 volts is used for the repeater. These voltages are available from power plants having battery reserve which are normally provided in offices where the repeater will be used. Use of the office battery power rather than rectified commercial alternating current avoids service interruptions that would result from failure of the commercial a-c supply.

Rapid Change of Operating Speed. Speed is controlled by a switch which selects a preadjusted tuning capacity for each desired speed. The possibility of a rapid change in speed permits a reduction in the number of spare repeaters which need be available in an office handling more than one speed. Three speeds—60, 75, and 100 words per minute—are provided by this unit.

Rapid Change Between 5- and 6-Unit Selecting Code. As described, the character-timing circuit operates with a code having five selecting elements. In order to function with teletypesetter code, which has six selecting elements, a resistance-capacitance timing and clamper circuit (one twin-triode, not shown) can be added to eliminate one of the counting impulses. In this way one extra cycle of sine wave will be generated before the counting circuit comes to a stop. When the additional circuit components are provided, switching between 5- and 6-unit code is done simply by removing or inserting the associated vacuum tube. No adjustment is necessary.

Reduction of Line Hits. In 2-condition signaling such as telegraphy, sporadic changes in condition during a mark or space signal are called hits. A regenerative repeater will eliminate hits which do not occur during the sampling impulse with one important exception. A spacing hit

Figure 2. Functional schematic of the regenerative repeater



during a stop element or idle period will act the same as an incoming start signal. Unless the hit is extremely short, it will cause the repeater to begin its cycle of operation. This is actually the worst sort of hit, since it may put a start–stop system out of synchronism for many characters, particularly if the signals go through several pieces of start–stop synchronized apparatus. Electronic regenerative repeaters tend to be very susceptible to this trouble because of their rapidity of response. One type of mechanical regenerator which is now being used requires about two milliseconds to unlatch, whereas an electronic trigger device ordinarily will act in a few microseconds.

This repeater eliminates most of the susceptibility to false unlatching by not starting the synchronizing action of the character timing circuit until one-half element after

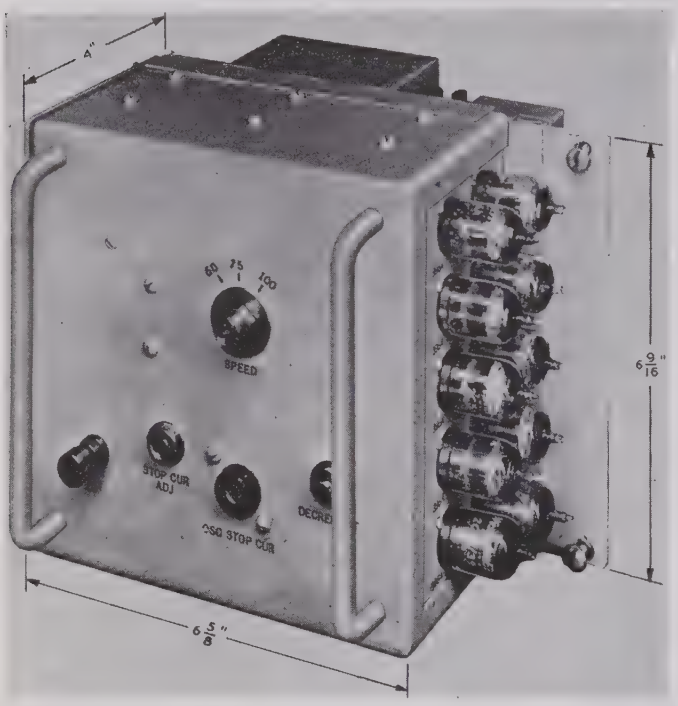


Figure 3. The 143A regenerative repeater

the beginning of a code character—that is, at the time of selection of the start pulse. This means that a hit of less than 11 milliseconds (one-half element at a speed of 60 words per minute) will not unlatch the repeater. The sine wave oscillator will begin a cycle but will return to steady state soon after the end of the hit.

Steady Space or Mark. When a steady mark is being received, the same conditions which stop the oscillator also actuate a circuit which is paralleled with the output circuit and insures a marking output signal. This avoids complete dependence upon the holding action of the output flip-flop tube and is required for a number of minor reasons not covered here.

When a steady space is being received the oscillator never stops and the mark-restoring circuit just mentioned is never actuated. Accordingly, a series of uninterrupted spacing selections is made. Retransmission of an uninterrupted space is valuable when break circuits or timing circuits are connected on the line or when manual Morse signals must go through the repeater.

Partial Regeneration of the Stop Element. Because of its indefinite length, the stop element of a start–stop signal cannot be regenerated; or, more accurately, the interval between two start transitions—that is, character length—cannot be regenerated. Even with automatic signals where the characters are all of the same length the stop element cannot be regenerated in the true sense, because there must be some amount of time provided, however small, for the regenerator to come to rest in order for it to operate on a start–stop basis and permit some variation in the speed of the teletypewriter transmitters.

Since it is not regenerated, the stop element may suffer cumulative distortions, especially in circuits having more than one regenerated section in tandem. Transmission circuits having long time constants, speed errors, and fortuitous effects contribute to changing the character length, with a consequent fortuitous lengthening or shortening of succeeding stop elements. Properly, a regenerative repeater should limit the shortness of a stop element being retransmitted to prevent cumulative shortening to the point of failure.

This limiting action is best applied when the code system used has a stop period longer than the other elements. In this case the repeater regenerates the first element length of stop period in the same way as any other element is regenerated. When a foreshortened stop pulse is received the timing oscillator does not stop but, after causing selection of a one-element stop period, proceeds with timing of the next character. Recycling of the character timing circuit is not affected by the failure to stop, since character timing is merely a matter of counting the proper number of cycles for the second character after finishing the count of the first.

SYSTEM APPLICATION

The regenerative repeater being discussed was designed concurrently with a new hub-type method of multibranch operation. The repeater itself is simply a one-way device, but when incorporated with the new hub transmission system, each branch or spoke (one at a time) may send through the single one-way regenerator unit to all the other stations, thereby making efficient use of the regenerator. The hub-coupling circuits, one of which is associated with each branch, are voltage-operated devices and may be driven directly from the output of a vacuum-tube circuit; consequently, neither input nor output relays are required in the regenerative repeater. An additional saving in first cost, maintenance, and space results.

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Electrical Application Problems for Engineering Education

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Because the engineering graduate of today does not fully appreciate the extreme gradation of job types in his field, the engineering schools not only should train the student thoroughly in his subject, but should provide him with a knowledge of where his particular talents can best be applied. One method which can aid in attaining this end is to use actual practical problems from industry in senior courses and as thesis subjects. This article, the third in a series,* presents some typical electrical application problems.

TODAY'S technical engineering graduate does not have a full appreciation of the extreme gradation of job types in the fields he is qualified to enter. In his academic training, he has intensively studied mathematics, chemistry, physics, electrical theory, mechanics, and a host of allied subjects. However, the multitudinous ways in which industry puts such academic training to work has been given only a minor place in the engineering school curricula. This is indeed unfortunate, because graduate engineers are finding jobs fewer and harder to obtain, and the engineer should not only be equipped with a full set of technical tools and a thorough knowledge of how to use them, but he should also know where and how industry uses the engineer with his tools and knowledge.

Just what does the application engineer do in working with a customer on a project, where the need and desire is definite? His first act, of course, is to contact the customer and his engineers to evaluate the problem. This contact is sometimes made by letter, but a personal contact has been found to produce the best and most satisfactory results in industrial work.

The application engineer, of course, must be familiar with the customer's industry (the personnel of the industry, what products it produces, what these products are made from, how much they cost, what equipment is used to make the products), along with a comprehensive knowledge of the power and operational requirements of such equipment (the conditions under which the equipment must operate, how the equipment will be maintained, the quality of operating personnel, and other related facts). Armed with these facts and thoroughly grounded in the application of his own company's products, the application engineer is able, through study and calculation, to select the type, rating, and combination of equipment necessary to produce a desired result.

The application engineer's job does not stop here, however, as he must maintain continuous contact with important engineering work in the industry in which he is engaged. Major installations should be visited after the equipment is in place and running order, to check performance and determine what improvements can be made on future applications. Then too, the application engineer is in a favored position to carry on promotional activities for his company. He takes an active part in national association committee work; he prepares papers for district and national meetings; he gives talks before engineering groups; he prepares articles for trade and technical magazines; he conducts classes in application engineering subjects; he trains other engineers; he prepares engineering memoranda and letters covering engineering tests and investigations and assists in the preparation of engineering material for bulletins and leaflets.

One might conclude at this point that the activities of the application engineer are such that he must be highly specialized. If this statement is considered from an industry viewpoint, it would be correct. Over a period of time an application engineer tends to specialize in one or more industries which have closely related interests. Certainly industries like central station, transportation, metal working, mining, petroleum, paper, rubber, textiles, marine, and many others, each have enough depth that an application engineer might specialize in a single field and still be learning from the field after a fruitful life of work in it. There are some 1,200 different industries in the United States and about 500 are major ones that supply fully 85 per cent of the nation's goods and services. Some of these industries are best served by product specialists who are combination application engineers and sales engineers. This is particularly true where certain segments of many industries are served by businesses supplying one type of product, such as small motors, lighting, elevators, X-ray equipment, or air conditioning.

The central station industry differs from other industries in that many central station companies have their own application engineers, who do the normal application work. This means that in many cases the problems handled by the manufacturer's central station application engineers are of a specialized nature, requiring extensive theoretical treatment. For this reason the manufacturer's central

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* Previous articles in this series were "Industrial Electronic Problems for Engineering Education," by Walther Richter (*EE, Dec '49, pp 1041–3*) and "Design Problems for Engineering Education," by T. M. Linville and K. B. McEachron, Jr. (*EE, Jan '50, pp 29–33*).

station engineers' group must be highly skilled theoretically and capable of analyzing complicated system problems.

To represent the scope of an important problem, the problem of voltage regulation and lamp flicker utilizing series capacitors was selected for Section I of this article because there is considerable need for further extensive work in this field. A number of problems which could be used for thesis work concludes this section.

In the general industrial fields, and in the processing industries in particular, there is a growing need for technically trained personnel. Many plants that have operated for years at a profit, now find themselves marginal and require advanced technology in modernizing and expanding their plants to remain competitive. This is opening up new fields for the engineer and application engineers in considerable numbers will be needed.

Today the industrial worker has about 7.5 horsepower backing him up, with most of the power electric. The industrial application engineer then is mostly concerned with machines used in manufacturing and processing, with a high proportion of his work in motor drives and the power supplies necessary for their operation. Constant-speed drives are usually alternating current, using conventional standardized equipment. Variable-speed drives are predominantly direct current, utilizing motor-generator sets for power supply. Single-motor drives are in the majority and are usually more easily applied than complex drives, utilizing two or more motors. With special attention being given to increasing output on both old and new machines, there is a trend toward more fully automatic operation, which requires that the application engineer be familiar with complete systems and the way the various components operate in the system. As an example of the engineering required in applying apparatus to the mining industry, Section II presents a representative application and indicates a number of problems which are of importance in application work.

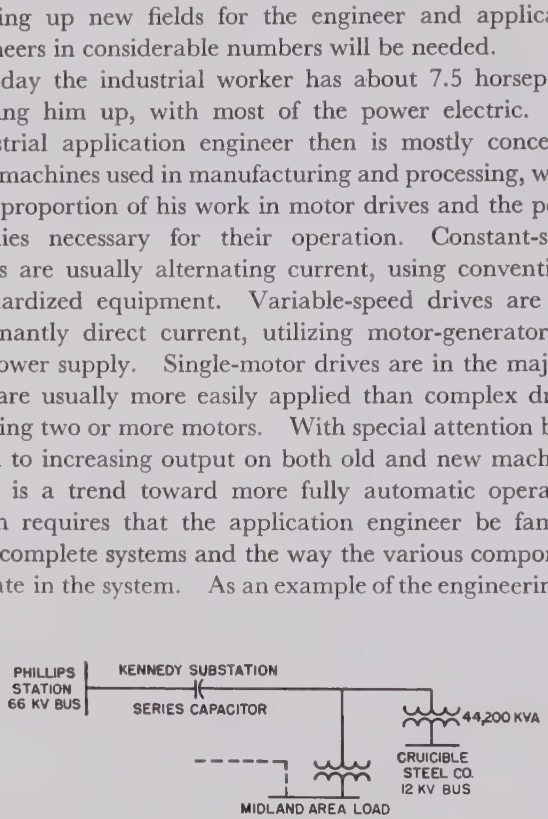

Figure 1. Circuit diagram of the Duquesne Light Company 66-kv system to the Crucible Steel Company

I. Power System Application*

A TYPICAL APPLICATION

Many power system problems encountered by the application engineer would make satisfactory thesis projects for engineering students. Three typical problems will be discussed in connection with a 66-kv series-capacitor installation made in 1947. The satisfactory performance of this particular application during the past two years is evidence that all important problems were solved; however, this does not mean that further investigations cannot be made to advantage in the general field of series capacitor application. Actually, additional concentrated study is indicated in three specific phases of these applications.

In October 1947, the Duquesne Light Company placed in service a 10,000-kva series capacitor to improve voltage regulation and to minimize light flicker produced by the operation of four 10,000-kva electric arc furnaces at the Crucible Steel Company plant.[1–3] The latter plant is supplied from the Duquesne Light Company Phillips Station over a 14-mile 4/0-copper 66-kv transmission line as shown in Figure 1. The steel company receives power from the 66-kv line through four 66/12-kv transformer banks having a total rating of 44,200 kva. The principal load at the plant consists of four 10,000-kva electric arc furnaces, one 4,000-horsepower induction motor (motor-generator set), two 3,000-horsepower synchronous motors, two 1,000-kva synchronous motor-generator sets, and one 800-horsepower synchronous motor. Prior to the capacitor installation, the rapidly fluctuating loads drawn by the arc furnaces produced instantaneous voltage variations of approximately eight per cent on the steel company's 12-kv bus.

These voltage variations, which may have a frequency as high as one per second, are generally termed lamp flicker because of their effect on mazda lamps. The Crucible peak load of 28,600 kw at 78.3 per cent power factor caused the 12-kv bus voltage to drop approximately 18 per cent from its no-load value. The operation of the arc furnaces also produced effects other than those at the Crucible plant. For example, the 66-kv line is tapped to serve load in the Midland area. Because of the voltage fluctuations on the 66-kv line, this area was normally served from a 22-kv line back to another source.

The principal problems presented in this application were the lamp flicker and excessive voltage regulation at the Crucible Steel plant, and lamp flicker at other points on the 66-kv system, particularly on the Midland tap. Consideration was given to other corrective measures, such as step-type voltage regulators, switched shunt capacitors, and synchronous condensers, before arriving at the decision to use a series capacitor. All of these schemes were discarded as being technically unsuited or economically unfeasible for the application. The series capacitor was selected because it was less expensive then any other method of satisfactory voltage control.

Capacitor Location and Rating. The major part of the voltage drop on the Duquesne Light Company 66-kv circuit was due to the flow of lagging power factor current through the source and line reactances. This same current produces a voltage rise through a series capacitor, which means, in effect, that a capacitor decreases the net reactance of a circuit. In order to be effective the capacitor must be located on the source side of the point in the circuit where improvement of voltage conditions is desired. In the Duquesne Light Company case it was deemed highly desirable to decrease the voltage variations on the Midland tap so that the Midland area load could be supplied from the 66-kv line. For this reason, the capacitor was installed in the 66-kv line ahead of the Midland tap.

* This section was prepared by R. L. Witzke.

The capacitor has a rating of 13.5 ohms reactance, and 500 amperes continuous, 675 amperes for 30 minutes, and 750 amperes for five minutes, these capacities being adequate for the anticipated circuit loading.

A parallel resistor was included to prevent self-excitation of large motors at the Crucible Steel plant. The resistor assembly in each phase includes four 400-ohm resistors, which can be operated in parallel combinations to give resistance values of 100, 200, 300, or 400 ohms. A minimum value of 100 ohms was included in the design because it is difficult to predict the actual resistance required, at least at this stage of the art. Field tests have shown that satisfactory performance can be obtained with 400 ohms.

Consideration was also given to the possibility of ferroresonance between the series capacitor and large transformers at the Steel Company plant, and to hunting of synchronous and induction motors. Preliminary studies led to the conclusion that trouble should not result from these causes, at least not with a resistor in parallel with the series capacitor. Operating experience to date has substantiated these conclusions.

THESIS PROJECTS

The cost of the parallel resistors in a series capacitor installation may be as high as the capacitor itself, including all of the protective equipment, which makes it evident that a reasonably accurate predetermination of the resistor requirements is very desirable. This requires a detailed consideration of ferroresonance, self-excitation, and hunting possibilities. In some instances the cost of the necessary investigations exceed the cost of all the equipment required for an installation. The series capacitor is ideally suited to many applications but is handicapped by a lack of fundamental information on resistor requirements. Engineering schools can be of assistance by devoting research time to the three special problems encountered in these applications. Fortunately, these three problems are separate and distinct, and can be treated independently. Each problem would make a suitable thesis project.

1. Ferroresonance. When a transformer is energized at the instant the supply voltage passes through zero, a high inrush current will be drawn by the transformer. This current lasts for a fraction of a second, after which the transformer draws its normal exciting current. If the transformer is excited through a series capacitor, ferroresonance may result, in which case the transformer will continue to draw a very large exciting current under steady-state conditions. This can be prevented by an appropriate resistor in parallel with the capacitor. As one of the circuit elements, the transformer, is nonlinear, a simple analytical solution is impossible. Butler and Concordia[4] have investigated this problem, and give valuable data on resistor requirements for a number of circuit conditions. This work should be expanded to cover a wide range of source impedances, series capacitor reactances, and transformer saturation characteristics. Consideration should also be given to the influence of shunt loads on the phenomenon. A new approach to the problem may be required because most schools will not have access to a differential analyzer as used by Butler and Concordia.

2. Self-Excitation of Motors. When an induction motor is connected to a source of power through a series capacitor, self-excitation may be encountered. The circuit consisting of the motor, series capacitor, and power source has a natural frequency somewhat lower than the system dynamic frequency. If the motor is operating at some speed higher than the speed corresponding to this natural frequency, it may act as an induction generator and supply low-frequency

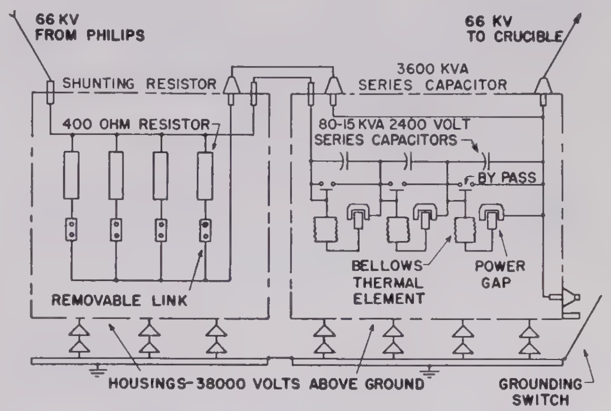

Figure 2. Diagram of Kennedy Substation showing capacitor shunt resistor, and protective devices

power to the system. The low-frequency current will increase in magnitude until the losses in the circuit are equal to the power produced by the negative resistance in the motor. The current is limited in magnitude by the ability of the 60-cycle circuit to supply power to the natural frequency circuit, the transfer of power between circuits taking place in the motor. These large, lower frequency currents may be present during starting or at normal motor speed. During starting, the negative torque produced by these currents may exceed the torque produced by the 60-cycle currents, in which case the motor may continue to run at some reduced speed.

Self-excitation can be controlled by the use of resistance in parallel with the series capacitor. The amount of resistance required is a function of the series capacitor reactance and the motor locked rotor and magnetizing reactance. Typical values are given in a paper by C. F. Wagner.[5]

Experience has shown that shunt loads are also beneficial in minimizing difficulties from self-excitation. For example, one series capacitor application performed satisfactorily for an extended period of time without a parallel resistor, but gave trouble when a large motor was started over a week end when all plant load was shut down. Additional information is required on the influence of shunt load impedances on self-excitation of induction motors. The facilities in most college laboratories are suitable for investigations in this field.

3. Hunting of Synchronous Machines. Synchronous motors, connected to a power supply through a circuit having a high ratio of resistance-to-reactance, will have a tendency to hunt, especially at light load. Transmission circuits of normal design usually have resistance-to-reactance ratios sufficiently low to prevent important hunting difficulties,

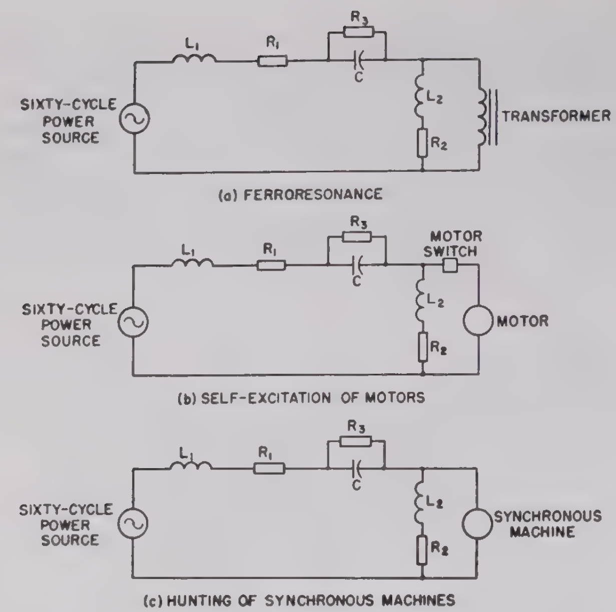

Figure 3. Simple diagrams illustrating essential circuit constants involved in ferroresonance, self-excitation, and hunting

R_1, L_1 = Source and line resistance and inductance
R_2, L_2 = Shunt load resistance and inductance
C = Series capacitor
R_3 = Parallel resistor

so this has not been a particularly significant problem in circuits without series capacitors. The addition of a series capacitor increases the resistance-to-reactance ratio, by decreasing the circuit reactance, and thereby increases the tendency of synchronous machines to hunt. As in the case of ferroresonance and self-excitation of motors, shunt resistors are effective in preventing important hunting problems.

Wagner,[6] Butler and Concordia,[4] and Concordia and Carter[7] have discussed this general problem in AIEE papers, and have established a basis for evaluating hunting possibilities in certain specific applications. Concordia and Carter indicate the values of series and shunt resistance required to obtain stable operation of a synchronous machine connected to an infinite bus through a series capacitor. This work could be extended to include the effects of system impedance and shunt loads. One specific case on which data are lacking involves a synchronous machine connected to a system of finite impedance through a series capacitor, with shunt load at the machine terminals. The synchronous machine may be a generator supplying power to the local shunt load, a motor drawing power from the system, or a synchronous condenser used for voltage control.

II. Industrial Application*

In addition to familiarity with electric apparatus, the application engineer must have a thorough knowledge of fundamental mechanics and of the processes and machines in the industry which he serves. Such knowledge is necessary in order to select and specify apparatus which will give successful performance under the operating conditions imposed by the particular industry.

For intermittent or cyclic duty problems such as cranes and hoists the determination of motor rating and control characteristics becomes an engineering problem, often of considerable magnitude. The following simplified problem of a balanced mine hoist illustrates the calculations required for a comparatively simple drive. Such problems are typical of the work of an industrial application engineer.

A SAMPLE SOLUTION

The following data are supplied:

Power supply	2,200 volts, 3 phase, 60 cycles
Hoisting distance	1,085 feet
Angle of shaft	90 degrees
Weight of load	11,500 pounds
Weight of car	5,500 pounds
Weight of cage	11,000 pounds
Rope diameter	$1^1/_2$ inches, 3.55 pounds per foot
Type of drums	Double cylindrical
Diameter of drums	9-foot pitch diameter
WK^2 of drums, gears, sheaves, and so forth	1,000,000 pound-feet squared
Operation	Balanced
Caging time per trip	8 seconds
Running time per trip	44.8 seconds
Total time per trip	52.8 seconds

Assuming ten seconds for acceleration, ten seconds for deceleration, and 24.8 seconds at full speed, the following are calculated:

Maximum rope speed	1,872 feet per minute
Maximum drum speed	66.3 rpm
Distance traveled during acceleration	156 feet
Distance traveled at full speed	773 feet
Distance traveled during deceleration	156 feet
Angular acceleration or deceleration, radians per second per second	0.694

To obtain the acceleration forces or torques, it is necessary to include the motor inertia in the calculations. The probable size of the motor may be estimated as follows:

$$\text{Horsepower} = \frac{(\text{weight of load})\times(\text{maximum rope speed})\times 1.4}{33{,}000\times 0.8\ (\text{mechanical efficiency})}$$

$$= \frac{11{,}500\times 1{,}872\times 1.4}{33{,}000\times 0.8} = 1{,}140 \text{ horsepower}$$

Here, 1.4 is an empirical factor to allow for cyclic losses. The motor size is taken as the nearest standard rating of 1,250 horsepower, 440 rpm, wound-rotor induction-type, WK^2 25,000 pound-feet squared. The gear ratio is then 6.64 to 1. The inertia or MK^2 of all parts referred to the drum shaft is

Motor	34,500
Total suspended load	33,800
Drum, gears, sheaves, and so forth	31,056
Total	99,356

With the foregoing data, the various moments over the duty cycle can be calculated (Table I). The friction load for this type of hoist is assumed as 7.5 per cent of the total suspended load—0.075 × 53,730—4,030 pounds.

* This section was prepared by W. R. Harris.

Table I. Calculation of Moments Over the Duty Cycle

Moment	Lbs Unbalanced Load	Lbs Unbalanced Rope	Ft Drum Radius	Unbalanced Lb-Ft Moment	Lb-Ft Friction	Lb-Ft Acc–Dec	Lb-Ft Total Moment	Time	P
M1	11,500	+3,850	4.5	69,100	18,150	68,400	155,650	0.0	1,960
M2	11,500	+2,750	4.5	64,100	18,150	68,400	150,650	10.0	1,900
M3	11,500	+2,750	4.5	64,100	18,150	none	82,250	10.0	1,040
M4	11,500	−2,750	4.5	39,400	18,150	none	57,550	34.8	725
M5	11,500	−2,750	4.5	39,400	18,150	−68,400	−10,850	34.8	−137
M6	11,500	−3,850	4.5	34,400	18,150	−68,400	−15,850	44.8	−200

M1 = Moment at start of acceleration.
M2 = Moment immediately before end of acceleration.
M3 = Moment immediately after end of acceleration.
M4 = Moment immediately before start of deceleration.
M5 = Moment immediately after start of deceleration.
M6 = Moment immediately before end of deceleration.

The total moments are used to calculate the horsepower (P) values at various points of the duty cycle. The actual horsepower at the start and end of each cycle is zero because the speed is zero, but since the motor heating varies approximately as the square of the torque it is necessary to multiply the moments by full speed in order to obtain the proper values for the correct determination of rms motor rating.

A hoisting duty cycle plotted from Table I is shown in Figure 4. The negative values indicated during the deceleration period with an a-c motor do not represent power returned to the motor but indicate that braking torque is necessary to decelerate the hoist in the time allowed. The relatively light values required for braking on this cycle could be supplied readily by manipulation of the drum brake.

To determine the size of motor, consideration must be given to the continuous rating and maximum torque required. The method commonly used to determine the rating necessary to operate continuously on the duty cycle without overheating is that known as the root-mean-square, which is based on the assumption that the heating of the motor is proportional to the square of the power output. While this is not strictly correct, it is usually close enough for practical purposes and has the advantage of eliminating the necessity of referring to test data of the motor losses,

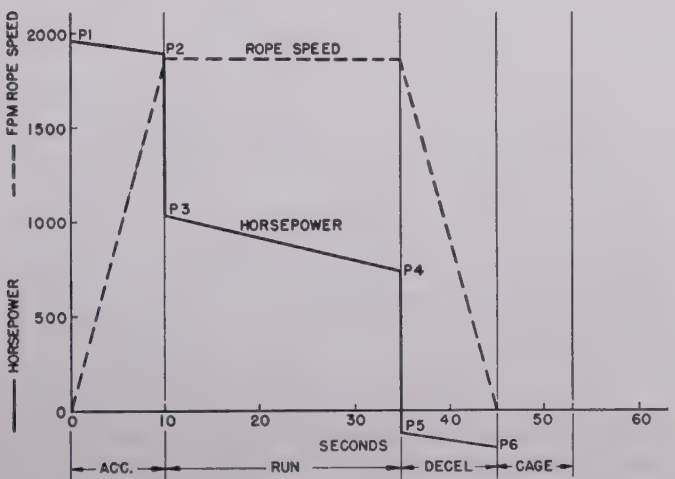

Figure 4. Hoisting duty cycle for a balanced mine hoist

which are seldom available to anyone except the electrical manufacturer.

As the name implies, the root-mean-square method consists in taking the square root of the average value of (horsepower^2 $\times$ time) for the entire duty cycle. To allow for reduced rates of cooling during the rest period and during the accelerating and decelerating periods, with a motor of

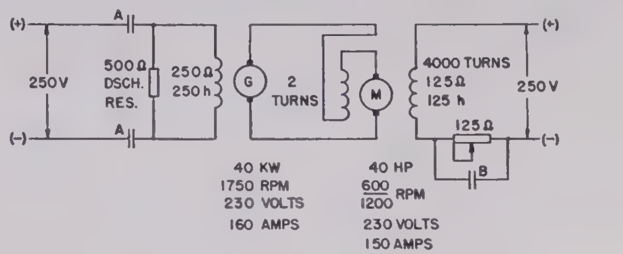

Figure 5. Connections and constants of a typical adjustable voltage system

the type and speed which are being considered in this calculation, it is customary to take only one-quarter of the rest time and one-half of the accelerating and decelerating time as effective for cooling.

$$\text{Horsepower}^2 \text{ seconds accelerating} = \tfrac{1}{2}(\overline{1{,}960^2} + \overline{1{,}900^2})10 = 37{,}249{,}000$$

$$\text{Horsepower}^2 \text{ seconds full speed} = \frac{(1{,}040)^2 + (725)^2 + (1{,}040 \times 725)}{3} \times 24.8 = 19{,}500{,}000$$

$$\text{Total horsepower}^2 \text{ seconds} = 56{,}749{,}000$$

$$\text{Rms horsepower} = \sqrt{\frac{56{,}749{,}000}{\frac{10}{2} + 24.8 + \frac{10}{2} + \frac{8}{4}}} = 1{,}240 \text{ horsepower}$$

TYPICAL PROBLEMS

The following problems are typical of those which confront the industrial application engineer.

1. *Regenerative Braking.* Figure 5 indicates the connections and constants of a typical adjustable-voltage system.

Assume straight-line saturation of both motor and generator with one ampere in generator field at 230 volts and two amperes in motor field at 600 rpm, 230 volts. The total armature circuit resistance is 0.2 ohm. WK^2 at motor shaft is 200 pound-feet squared. Friction load is estimated constant at 30 pound-feet.

In many such systems the motor is regeneratively braked from full speed by opening contactor A. Often contactor B is closed simultaneously to apply full motor field strength to obtain higher braking torques. There may be appreciable flywheel effect in the driven machine and it is necessary accurately to calculate the transient performance to see that accelerating and braking times are met and that the armature currents do not exceed safe commutating limits.

For the system shown, calculate speed-time and current-time curves for regenerative braking from full speed by simultaneously opening contactor A and closing contactor B. Determine the effect of changing the discharge resistor

value. Develop formulas for each of the following general cases:

(*a*). With no motor series field.
(*b*). With cumulative motor series field.
(*c*). With differential motor series field.

2. *Speed Correspondence of D-C Motors on Adjustable-Voltage Systems.* Processing lines in the steel, paper, rubber, and textile industries are usually driven by adjustable-voltage systems in which several motors of different ratings are sup-

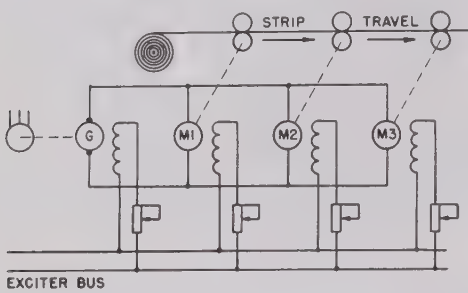

Figure 6. Typical adjustable-voltage process line drive where it is necessary to maintain strip tension between machine sections at all speeds

Motor number	*1*	*2*	*3*
Rated horsepower	*50*	*20*	*30*
Rated volts	*230*	*230*	*230*
Rated amperes	*180*	*75*	*107*
Rated rpm	*1,200*	*1,200*	*1,200*
Armature circuit resistance	*0.050*	*0.200*	*0.111*
Load amperes	*100*	*75*	*90*

plied from one d-c generator. These lines may be required to operate over speed ranges of ten-to-one or greater, and the speeds or loads of the various motors must be proportional over the required range. The problem is difficult because different armature circuit *IR* drops destroy speed relations at low voltages.

Process lines are usually operated with tension in the strip between the motorized sections. It is necessary to keep tension relatively constant to prevent either excess tension or the formation of a loop. For most drives it is not desirable or economical to provide automatic regulating equipment and careful attention must be paid to motor characteristics to assure successful operation.

Figure 6 is typical of adjustable-voltage process line drives where it is necessary to maintain strip tension between machine sections at all speeds.

Assume that operation over a ten-to-one speed range (1,200 to 120 rpm) is obtained by adjusting the generator voltage. The motor field strength, after initial adjustment, is to remain fixed. Also assume that the friction load stays constant over the entire speed range. Specify the material to be connected into the armature circuit of the motors to assure approximately equal speeds and strip tension at all generator voltages. (Do not use regulating equipment.)

It is often desirable to accelerate quickly, and maintenance of relative speed and tension during acceleration is important for successful operation. Flywheel effect of adjacent sections may be widely different. Assume in the example given that the armature currents required for acceleration only are

Motor Number	Accelerating Current in Per Cent of Full Load
1	100
2	50
3	70

What can be done to assure successful operation both during acceleration and at steady running speeds?

3. *Flywheel Motor-Generator Set Selection.* On reversing blooming and slabbing mill drives, d-c motors as large as 8,000 horsepower capable of frequently repeated loads of 225 per cent and occasional peak loads of 275 per cent may be required. The duty is cyclic. To smooth out the power required from the a-c supply system, it is common practice to use a flywheel motor-generator set to supply power to the mill motor. This set is driven by a wound-rotor induction motor operated with a liquid slip regulator designed to hold the power input to the motor at constant value by changing the rotor resistance. The flywheel must be of such size that the set will not slow down below 85 to 90 per cent speed at any point in the cycle. Table II shows a typical pass schedule.

Table II. Pass Schedule for Rolling 18- by 18-Inch Ingots to Four- by Four-Inch Billets

Pass Number	Rolling Horsepower, Seconds	Pass Duration, Seconds	Interval to Next Pass, Seconds
1	2,940	0.875	2
2	2,870	0.985	2
3	4,100	1.115	2
4	4,100	1.265	2
5	4,350	1.450	3
6	5,250	1.690	2
7	5,600	1.990	2
8	5,680	2.300	2
9	6,100	2.700	4
10	6,500	3.160	2
11	7,100	4.720	2
12	7,300	4.380	2
13	8,150	5.170	4
14	8,250	6.030	2
15	8,850	7.020	2
16	9,300	8.200	2
17	9,250	9.420	4
18	10,000	10.800	2
19	10,850	12.500	2
20	11,400	14.300	3
21	9,800	16.000	15

Repeated for following ingot.

The mill driving motor is rated 2,000 horsepower, 50/120 rpm, 225 per cent frequently repeated loads, 275 per cent maximum occasional peak load, WK^2 of motor and mill 500,000 pound-feet squared. Specify the flywheel motor-generator set rating including flywheel stored energy, wound-rotor motor rating, and recommend a slip regulator setting. Base calculations on the rolling schedule of Table II and on a minimum flywheel set speed of 85 per cent. Also calculate the average loss in the slip regulator.

4. *Squirrel-Cage Induction-Motor Rotor Losses.* The squirrel-cage induction motors are frequently applied to duty cycle applications where the cost of a more expensive variable-voltage drive is not economical. A typical duty cycle consists of accelerating to full speed, running a short time,

and stopping. A typical application is to sugar centrifugals where it is necessary to accelerate to top speed quickly and to stop quickly in order to meet production schedules. During the operating cycle considerable losses occur, particularly in the motor rotor. These losses must be calculated before the proper motor selection can be made. Two-speed squirrel-cage motors are used and the control is arranged to accelerate the motor to approximately one-half speed by applying full voltage to the low-speed winding, then to accelerate to full speed by applying full voltage to the high-speed winding. The centrifugal is decelerated by applying full voltage to the low-speed winding until approximately one-half speed is reached at which time the motor is disconnected and mechanical braking applied.

Consider a 6/12-pole 60-cycle squirrel-cage motor direct-connected to a centrifugal which requires the schedule of 40 seconds for acceleration, 20 seconds running time, and 40 seconds for deceleration. The WK^2 at the motor shaft including both motor and basket is 9,500 pound-feet squared. Assuming a negligible friction load, calculate the rotor losses during one cycle of operation including starting, running, and stopping. If the ratio of secondary resistance to primary resistance is four to one, estimate the total motor losses neglecting iron loss.

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Electrical Essay

Self-Running Electrostatic Motor

My inventive ability has got me in a fix. I was doing a repair job on the Van de Graaff atom smasher up at the Research Laboratory and got to thinking about the forces on electric charges like the books talk about. I cooked up the following.

Two endless insulating belts run round pulleys like in Figure 1. These belts are each kept charged equally and oppositely by high-voltage corona points as in Figure 1, and the belts are moved around until they are charged all over, uniformly. Of course for any position of the belts, the electrostatic forces balance. The attractions of the opposite charges on the upper parts of the belts are just balanced by the attractions of the opposite charges on the lower parts of the belt.

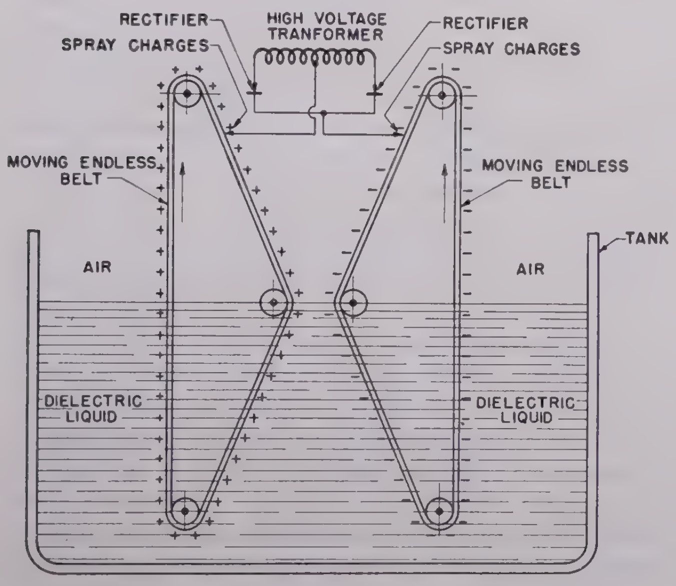

Figure 1. Self-running electrostatic motor

Now I change all this by immersing the lower halves of the belts in inerteen oil. Besides being fireproof, this inerteen oil has a dielectric constant of five, so according to what the books say, the attractions of the charges on the lower parts of the belt will be reduced by five so that they no longer balance the attractions of the charges on the upper parts of the belts. The belts will start rotating therefore, the inner nearer parts moving downward, and the outer parts moving upwards.

Now I am proud of being an inventor of space ships, but this last invention looks like perpetual motion, and I don't want to have none of that! How can I get out of this?

J. Slepian, Alter Ego

J. SLEPIAN (F '27)

(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Answers to Previous Essays

Electrostatic Space Ship. The following is the author's solution to a previous essay (*EE, Feb '50, p 164*).

Yes, Alter Ego, you are good, not as an inventor, perhaps, but for raising very interesting basic theoretical questions. You raise too many of these to discuss properly in this one essay, but perhaps we can get to them in the next few essays, dealing with electrostatics and magnetostatics which I expect you will write.

Your equation 1, Coulomb's law, $F=q_1q_2/r^2$, for charged small bodies in empty space, and your equation 2, Lorentz's force equation for a small charged body at rest in empty space, $\mathbf{F}=q\mathbf{E}$, serve to define the charge q on a small body

located in empty space, and the electric force or intensity **E**, at the various points in empty space. The **F** in equation 1 is a mechanical or "ponderomotive" force, or better, it is determined by examining the known and recognizable mechanical forces acting on the probe or small charged body, and noting that these known mechanical forces fail to balance according to the laws of mechanics. The electrical "ponderomotive" force **F** of equations 1 and 2 is then invoked to restore the balance. Thus Coulomb observed the twist on a suspension string holding up a horizontal rod with a charged metal sphere on its end. This twist on the suspension string needed something to balance it according to his Newtonian mechanics. Defining **F** as that mechanical force which would supply this balance, he experimentally established his equation 1.

With **F** defined thus, through the failure of mechanics to be sufficient, experience teaches us that for a large class of experimental conditions, we may correlate and properly describe all the **F**'s which we observe, by means of a vector field in space **E**, and a scalar q characterizing each charged small body with q, **E**, and **F** related by the Lorentz equation 2. Equations 1 and 2 then serve to define the q's, and **E**, and experiment tells us that the **E**'s and q's defined in this way will be consistent. Furthermore, experiment tells us that the scalar, q, found and defined in this way satisfies a conservation law. That is, if two small bodies with charges q_1 and q_2 respectively are brought together to make a single charged small body, then its charge q will be equal to q_1+q_2. Conversely, if a single small body with charge q is broken up into two small bodies with charges q_1 and q_2, then $q=q_1+q_2$.

If we generalize equation 2 to the complete Lorentz force equation 3, $\mathbf{F}=q(\mathbf{E}+1/c[\mathbf{v}\times\mathbf{B}])$, then the equations 1 and 3 may be said to define the scalar q for any charged small body, and two vector fields **E** and **B** in empty space.

We see from the foregoing that the charge q on a small body, and the fields **E** and **B** in empty space in which it is said to find itself, rest for their definitions on the complete knowledge on the part of the observer of small body or particle mechanics. Fortunately, relativistic particle mechanics differs very little from Newtonian particle mechanics for small bodies moving with small velocities relative to the observer, so that our experiments establish equations 1 and 2 and 3 for either mechanics. However, our experiences in electron and atom physics lead us to expect that if we ever become able to move small charged bodies with great enough velocities we will need to use **F** as given by relativistic particle mechanics to define q, **E**, and **B**, uniquely and consistently.

Again, from the foregoing definition of **F** through mechanics, we may speak only of the force on a charged small body, and not of the force on the charge itself, Alter Ego and many books notwithstanding, as if that last somehow had meaning and was distinguishable from the total unbalanced mechanical force on the charged body. Thus Millikan determined the charge of the electron by observations of the mechanical forces on a small oil drop in a uniform electric field, and did not need to ask what electric force was acting on each of the myriad protons and the myriad plus one electrons making up the oil drop.

Stating that a single scalar quantity, q, with the fields **E** and **B**, serve to describe completely the force **F** on small enough charged bodies, succinctly describes an extremely important result observed in Coulomb's and similar experiments, and which is very seldom explicitly stated. Coulomb's law stated completely should be, "the force of repulsion, one upon the other, of two isolated small enough charged bodies is q_1q_2/r^2, and is independent of the shape, size, and the material making up the small enough bodies. Thus Coulomb in his experiments would have found that his results would be the same whether his small bodies were spheres, ellipsoids, tori, or other shape, made of copper, gold, U-235, or even one "titanate" and the other glass. Thus we throw out the basic premise upon which Alter Ego's invention is based.

In his misapplication of Coulomb's law, equation 1, Alter Ego was probably misled by his confusion concerning the Lorentz law, equation 2. What is the **E** which gives the force of $q\mathbf{E}$ on the small charged body? Is it the "actual **E**" at the small body, which we might try to determine by using a still smaller probe or small charged body and observing the force on it when it is close to the given larger small body? No, such a trial would give most variable results, all differing from the proper **E** to use for Lorentz's equation. The proper **E** to use in Lorentz's equation for a small charged body in empty space is the unique ratio, $\mathbf{F}/q$, found for any and each of all small enough charged bodies at rest, placed at the point in empty space in question with no other body near it. The distorted field found around a small titanate body by probing with a still smaller charged body has no relevance to Lorentz's equation for a charged small body.

Now what can be meant by Coulomb's law of equation 1 as given by Alter Ego, for small charged bodies not in empty space, but in a medium of dielectric constant k? What can be meant by the Lorentz law for a small charged body not in empty space but within material?

In particular, how shall we define **F** in either case? The small charged body is imbedded in the medium, and if the medium is solid, it presumably holds the charged body at rest within itself by pressing upon the small body to restrain it from being moved by the "electrical ponderomotive force," $\mathbf{F}=q\mathbf{E}$. We expect then that a system of stresses is set up in the medium, which in themselves do not balance in their effect on the small imbedded body, and which by their unbalance define the electric force **E**. Thus the solid medium itself presumably plays the part of the twisted string and supporting rod of Coulomb's experiment.

How shall we determine these stresses in the medium? At first blush, one might say: "Observe the strains in the medium and then using purely mechanical elasticity theory and the appropriate mechanical elastic coefficients calculate the unbalanced stresses. This is essentially what we do for the twisted string and bar in Coulomb's experiment." This would be fine except that the phenomena of electrostriction and piezoelectricity intrude themselves. We find that even with zero charge on the imbedded small body, there are strains produced in the medium in the presence of an electric field, that is when the medium is near electrified bodies. The "stresses" cannot then be

calculated from a purely mechanical stress-strain theory.

If the medium is a fluid, and remains a fluid in the electrostatic field, the stresses presumably reduce to a hydrostatic pressure. Also, in this instance we may introduce additional mechanical forces by the action upon the small body of stretched fine strings or stressed fine rods. The electric ponderomotive force then presumably is determined not as equal to the effect of the twisted string, but there must be a correction due to the gradient of the "electrically induced hydrostatic pressure." In any particular experiment, the twist of the restraining string can be observed. It is the author's opinion, however, that no uniquely valid method can be found for resolving the force which equilibrates the string into a directly acting electric force, $\mathbf{F}=q\mathbf{E}$, and the effect of an electrically induced hydrostatic pressure gradient in the fluid.

For the case of two particles suspended in an infinite medium with uniform and unchanging dielectric constant k, it may be shown that under very general conditions the force equilibrating the twist on the string will be $\mathbf{F}=q_1q_2/kr^2$. However, how much of this force is to be attributable to $\mathbf{F}=q\mathbf{E}$ and how much to electrically induced pressures is a question which cannot be answered uniquely, and which is therefore meaningless.

In Abraham and Becker's "Electricity and Magnetism" (Hafner Publishing Company, New York, N. Y., 1932) on page 95, it is shown that with certain plausible assumptions as to the electrical properties of a compressible fluid, the force which would need to be impressed, by restraining strings perhaps, or by mechanical pressure gradients, upon a small volume $\Delta\tau$ of the fluid, charged with density ρ is given (not uniquely in author's opinion) by $f_e\Delta\tau$, where

$$\mathbf{f}_e=\rho\mathbf{E}-\frac{1}{8\pi}E^2 \operatorname{grad} k+\frac{1}{8\pi} \operatorname{grad}\left(E^2\frac{dk}{d\sigma}\sigma\right) \tag{4}$$

where σ is the density of the fluid. If we let the compressibility approach zero, then the second term will approach zero, but not the third in which $d\sigma/dk$ may be given any value. Thus the analysis of Abraham and Becker (which the author contends itself not unique) will not give a unique answer to the problem of what is the electric ponderomotive force density, per unit volume for an infinite incompressible fluid.

It is perhaps distressing that textbooks by eminent authorities give the equation 1 as being Coulomb's law for a dielectric medium without further clarification. Fortunately these books do not make any real use of this formula. It was Alter Ego's misfortune that he did try to do so.

Further discussion of proper definitions of **E** and **B** within material media, and what can be meant by electric ponderomotive forces will be given in the author's replies to subsequent essays.

J. SLEPIAN (F '27)
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Phase Sequence Indicator. The following is the author's solution to a previously published essay of the foregoing title.

The phase sequence indicator gives the expected performance at normal frequency and a sine wave form of voltage. Presence of harmonics may reduce, equalize, or even reverse the indication of the phase sequence indicator. Figure 1 presents a topographic voltage vector diagram illustrating the neutral shift of the indicator with respect to line voltages of various frequencies. The fundamental and $(3n+1)$ harmonics, being positive sequence voltages, displace the neutral to the right of the diagram. The $(3n+2)$ harmonics are negative sequence voltages and displace the neutral to the left of the diagram. In Table I the fractions of the line voltage harmonic components which appear in voltages impressed across the two lamps are tabulated for harmonics up to the 17th (note that the $3n$ harmonics are zero sequence voltages and cannot appear in line voltages).

Figure 1. Topographic voltage vector diagram illustrating the neutral shift of the indicator

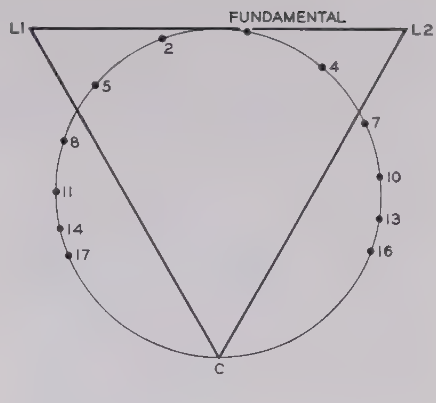

Table I. Fractions of Line Voltage Impressed on Lamps of "Phase Sequence Indicator"

Harmonic	Lamp 1	Lamp 2
Fundamental	0.58	0.42
Second	0.35	0.65
Fourth	0.79	0.25
Fifth	0.23	0.84
Seventh	0.93	0.27
Eighth	0.31	0.96
Tenth	1.01	0 40
Eleventh	0.44	1.03
Thirteenth	1.05	0.51
Fourteenth	0.54	1.07
Sixteenth	1.08	0.60
Seventeenth	0.61	1.08

By properly proportioning harmonics in a voltage wave of the line, it is possible to obtain equal rms voltages across the two lamps. A solution, however, is feasible only in the case of a voltage containing one harmonic. For example, if the voltage is assumed to contain the most common fifth harmonic only, the following two equations are established:

$$(0.58\,E_1)^2+(0.23\,E_5)^2=(0.42\,E_1)^2+(0.84\,E_5)^2$$

$$E_1^2+E_5^2=208^2$$

Their solution gives the fundamental and fifth harmonic components of the line voltage.

$$E_1=186 \text{ volts}$$

$$E_5=\ \ 92 \text{ volts}$$

(The engineer should request correction of the wave form by the power company before he attempts to operate the motor.)

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Conference Papers Digested for Winter General Meeting

These are authors' digests of most of the conference papers presented at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. These papers are not scheduled for publication in AIEE *Transactions* or AIEE *Proceedings*, nor are they available from the Institute.

Transformer Sound Level Considerations; *A. J. Maslin* (*Westinghouse Electric Corporation, Sharon, Pa.*).

The sound level resulting from the operation of a transformer is an exceedingly complex function of the materials, design, construction, service, and placement of the unit.

Driving forces, the more important of which reside in the core, induce mechanical vibrations which are ultimately transmitted as sound to the ear of an observer through the surrounding atmosphere. Core material, core construction, flux density, and flux distribution are important factors in the magnitude of the driving forces. The mechanical impedance and natural frequencies of the over-all structure determine the amplitude of the resulting vibration. When the forces and vibrations have been minimized as much as present knowledge and the requirements of the structure permit, about the only remaining variable under the control of the transformer designer is the flux density.

Reducing the sound level by reducing the flux density is an expensive procedure. Because the National Electrical Manufacturers Association recommended sound levels do not bear a natural relationship to transformer rating, the relative cost of a given reduction is greater for small- and medium-size power transformers than for large. The use of internal barriers of low transmission coefficient has been repeatedly advocated, but electrical, thermal, and other considerations have prevented their use. External barriers in the form of complete enclosures or surrounding walls are extensively used but are also expensive. They have the advantage of permitting architectural harmony with adjacent structures. The choice of the method of sound mitigation which is to be used should be determined chiefly by the economics involved.

Present NEMA recommended levels have been criticized as being too high. This is perhaps true for certain circumstances but not for all. To lower the present levels will exact an unjustified economic penalty from some users. Two or more sets of values keyed to different applications appear desirable.

The sound level meter is often criticized because its indications are not an accurate index of aural response. To rectify this condition a great deal of study will be required to insure against trading new shortcomings for old.

Quiet Transformer Installations—A Problem for Both Equipment and Substation Designers; *I. S. Mendenhall, F. L. Taylor* (*The Detroit Edison Company, Detroit, Mich.*).

With increasing load densities requiring the use of larger substation transformers, and the necessity for locating substations in or adjacent to residential areas, the problem of minimizing the noise emanating from these installations is becoming more acute for many electrical utilities.

It would appear to be possible to build transformers that are consistently much quieter than most of the units that are produced today, since such transformers have been built occasionally in the past. Any such effort on the part of the manufacturers would be of great help to the utilities in the solution of this problem.

The Detroit Edison Company has developed an enclosure for outdoor transformers that has proved satisfactory from the standpoint of noise, for transformers of ratings up to 10,000 kva, when installed in residential areas. This enclosure consists of 12-inch masonry walls on four sides, with the top left open for ventilation. A removable panel is built into one wall to facilitate changing the transformer.

An investigation has been made of the noise transmission characteristics and relative cost of three types of removable panels: brick built up with through-joints, ribbed sheet steel, and panels of 2-inch glass fiber batts completely enclosed in 20-gauge sheet steel. The tests indicated that brick panels should be used in locations where maximum noise reduction is essential; ribbed sheet steel is satisfactory where only moderate noise reduction is needed and cost must be kept at a minimum; and the enclosed glass fiber panels are a good compromise for many installations, since the noise reduction is much better than sheet steel, and the cumulative cost after two or more removals is less than brick.

The following table gives a comparison of the sound absorption and relative costs of the three types of removable panels, as determined from the experience of this company.

	Brick Panel	Sheet Steel Panel	Glass Fiber Panel
Reduction in sound level through panel at 70 decibels	24 decibels	12 decibels	20 decibels
Relative initial cost, installed	100 per cent	75 per cent	205 per cent
Cumulative cost after:			
One removal	206 per cent	85 per cent	214 per cent
Two removals	312 per cent	95 per cent	223 per cent

Manufacture of Electron Tube Parts by the Rubber-Die Technique; *William J. Bachman* (*Radio Corporation of America, Harrison, N. J.*).

This paper describes the investigation of the use of a punch and flat rubber surface for blanking, forming, and piercing sheet material in order to obtain, inexpensively and quickly, a limited quantity of identical metal parts necessary for the small-scale production of experimental electron tubes. The rubber-die technique is based upon the rupture of material along a preselected line. A sheet of metal is placed upon a template several times its thickness, pressure is applied through the rubber, and the sheet of metal ruptures along the outline of the template.

The hardness or temper of the rubber as well as the design of the rubber container is important to the success of this technique. Rubber that is too hard will have a short life. Rubber that is too soft will "crepe" at any small space between the die cavity and the punch pressure plate, and will become seriously damaged. Rubber having a hardness of about 65 to 70 durometer is most satisfactory and will give more than 3,000 pressings without a change of rubber.

The investigation also determined the very important relation between template thickness and material thickness. An optimum template thickness exists for each job and will produce a clean blank with a minimum of pressure. The optimum relation between template thickness and material thickness is given in a curve and is useful for materials 0.0005 to 0.010 inch thick. The ratio of template thickness to material thickness for several specific material thicknesses follows: 0.0005 inch, 19 to 1; 0.003, 14 to 1; 0.005, 12 to 1; 0.008–0.010, 10 to 1.

The rubber-die technique reduces tooling costs to less than one-tenth that of conventional hand dies. Less skillful labor is required to make the tool and the time required is reduced from days or weeks to hours. In addition, the problem of die storage is practically negligible because a space the size of a shoe box will hold the equivalent of a full cabinet of conventional dies.

Induction Preheater of Electrolytic Tin Plate for Flow Brightening With High-Frequency Rotating Equipment; *W. T. Thomas* (*General Electric Company, Schenectady, N. Y.*).

The use of high-frequency induction heating equipment is the only satisfactory method to flow-brighten tin plate at high speeds. Current is the limiting factor for obtaining high speeds with resistance heating while space is the speed limitation for gas heating.

By induction heating speeds up to 1,400 feet per minute have been attained and this limit is now being extended to 2,000 feet per minute. The installation of preheating equipment to the oscillator equipment speeds production by increasing line speed. The 9,600-cycle high-frequency rotating equipment is given preference over the oscillator equipment as the preheating induction supply for reasons of economy and efficiency.

The equipment consists of two 150-kw

440-volt 9,600-cycle motor-generator sets, amplidyne regulator generator control panels, one induction heating coil assembly with its high-frequency shunt capacitors for power factor correction, and coil switching contactors. Each 150-kw induction heating section consists of 12 coils connected in multiple. The induction coils and capacitors are connected in multiple hydraulically as well as electrically.

The first full-scale experimental tests were conducted at a large steel mill company. These test results checked very well with the theory developed. The largest quantity of tin plate produced is from 0.009 inch to 0.010 inch thick. Even though there is some flux cancellation, tin plate can be heated efficiently at 9,600 cycles. The over-all efficiency (actual 60-cycle power to Btu's in strip) for heating 30-inch$\times$0.010-inch thick strip at 9,600 cycles is about 68 per cent.

New Controlled Infrared Heat for Industry; *J. E. Kolb* (*Edwin L. Wiegand Company, Pittsburgh, Pa.*).

Since the beginning of infrared heating 15 years ago, the infrared lamp has been used extensively, particularly for paint baking. Based on new information of the phenomena taking place when paint is dried under infrared, it is appropriate to consider alternate infrared heat sources.

Based on three years of field testing it appears that a heater producing far-infrared radiation, as contrasted with the near-infrared rays of the infrared lamps, would be more efficient for some applications. The greater percentage absorption by the work of the far-infrared radiation accounts for this increased efficiency.

The newly developed enclosed resistance far-infrared heat source, the radiant heater, is one of the possible alternates. Because of the construction of this heater, there are a number of differences from the infrared lamp, It is nonbreakable due to its all-metal construction, controllable through a simple device permitting a wattage variation from 0 to 100 per cent, more efficient due to the greater absorption of the far-infrared, and uniform in the heating of the work.

The radiant heater has been used for paint baking on metal awnings, heating molds for soft balls, dehydrating granular plastics, degreasing sheet metal parts, drying ink on printing presses, maintaining foods hot in restaurants, drying pharmaceutical bottles, and baking sand cores for plumbing fixtures.

The radiant heater is worth considering for infrared heating applications.

Ballast Developments for Long Tube Lamps; *G. C. Harvey* (*General Electric Company, Fort Wayne, Ind.*).

Proper control of long-tube fluorescent lamps is more complex than the familiar hot-cathode switch-start type of lamps. Higher voltages, power, noise levels, and weight are the chief problems encountered in the design and development of ballasts for these lamps.

Both hot and cold cathode construction in lamps that vary in length, diameter, filling pressures, filling mixtures, and tube coating all add to the problem.

Many circuits have been developed and used for the control of these lamps, and each one has its distinct advantages and disadvantages.

Continued co-ordination between lamp, fixture, and ballast manufacturers with intensive development activity supplied on studies of new starting methods, standardization, mechanization, new materials, and new processes will continue to reduce the relative cost of lighting with long tube lamps.

Application and Installation of the Long Tube Fluorescent Source; *Bernard F. Greene* (*Lighting Consultant, New York, N. Y.*).

The trend in fluorescent lighting is toward the longer length lamps. The advantages of the long tube source include savings in the number of electrical connections necessary and in operating cost. Lamp efficiency is increased by use of the long tube since there is a fixed electrode loss and the lamp length is the ratio of the fixed electrode loss to the total watts conserved by the lamp decreases.

Long tube lamps may be installed in a multiple or series installation. In the multiple, one ballast is connected to operate several lamps. The series type of installation is used mainly in cold cathode types of fluorescent lamps and up to 14 8-foot cold cathode lamps can be connected to a single transformer.

For the series type of installation it is possible to design the lamp or lamp holders so that there will be no live parts when the lamps are inserted or removed. Several ways have been developed to accomplish this in the long tube lamp. One of these is a circuit protector which consists of a calibrated spark gap. In the event a lamp is removed with the circuit on, then the circuit is automatically opened.

The lighting of the future is planned lighting with larger light source areas. More and more the trends show the lighting in buildings will be built-in luminous ceiling lighting with long tube and the long life fluorescent lamps.

Design and Testing of Control Circuit Transformers; *J. M. Frank, A. J. Hauck* (*Hevi Duty Electric Company, Milwaukee, Wis.*).

In order to build low-reactance control circuit transformers for use with magnetic devices that require high inrush current and good voltage regulation at these high currents, it is necessary to have a knowledge of the factors that affect the reactance of the transformer. In order to use a low-reactance control circuit transformer to its maximum possibilities, it is necessary to draw regulation curves, the accuracy of which depend on the method of test.

The reactance of a transformer depends on the square of the number of turns, the thickness of the coils, and the spacing of the windings. The turns for an economical flux density and for a reasonable magnetizing current are fixed. However, the reactance can be reduced to approximately one-third of its normal value by means of an interleaved winding. As the regulation of a transformer varies with the power factor of the load and as most magnetic devices operate at low power factor, this reduction in reactance is very important since at low power factor the reactance drop of the transformers is very nearly in phase with the load voltage while the resistance drop is very nearly in quadrature with it.

Even though accurate instruments are used and reasonable care in reading these instruments exercised, errors of 35 per cent or more can easily be introduced if the reactance is measured by the wattmeter method. By means of a null method and the use of phase selective detectors independent balance of reactance and resistant components is possible, and accurate measurement of the components involved can be made. Adoption of this null method for determining the impedance characteristics has made it possible to furnish reliable regulation curves.

Operation of Bushings in Carbonized Oil; *W. R. Wilson, L. Wetherill* (*General Electric Company, Pittsfield, Mass.*).

Factors influencing deposition of carbon particles on the lower ends of circuit breaker bushings have been investigated to determine the extent to which the rate of accumulation could be reduced by design modifications.

Carbon particles in the oil may be attracted to the bushing insulating surface, and held there by the electrostatic force which pulls a conducting particle toward a region of greater electric stress concentration. Macroscopic stress concentrations resulting from the geometry of the bushing parts cause no significant forces. Microscopic stress concentration occurs around a carbon particle in oil under stress. This concentration may be distorted by inhomogeneities in the bushing insulating surface or abrupt change in dielectric constant at the bushing insulating surface and may thus cause a relatively large force on the carbon particle.

These conclusions were established by electric field calculations and confirmed by measurement of electric field strength in an electrolytic tank containing large-scale representations of particles and nearby insulating surfaces.

A test procedure was developed for making 8-hour accelerated carbon deposition test runs on full size bushings. The amount and type of carbon deposition occurring over a long period under service conditions was approximated. This procedure yielded much data on the effect of design modifications on carbon deposition performance and reinforced theoretical conclusions based on calculation and measurement of field strength.

It was found that carbon deposition on the bushing insulating surface can be substantially reduced or eliminated by using bushing insulators with a surface layer which is homogeneous, avoiding electric stress parallel to the insulator surface, and avoiding excessive stress intensity. A relatively low dielectric constant insulator surface layer eliminates the tendency to accumulate carbon even with relatively high stress.

Design features utilizing these principles are incorporated in bushings currently being manufactured.

Compandors for Telephone Circuits; *P. G. Edwards* (*Bell Telephone Laboratories, New York, N. Y.*).

The compandor as it now applies in the Bell System is a voice-operated device which is employed to improve the apparent signal-to-noise ratio of toll circuits. It does this

by reducing the range of signal volumes which are applied to the circuit in such a way that the average volume on the line is higher than it would be without the compandor. The original volume range is substantially restored by the device at the receiving terminal.

This operation is performed on a syllabic basis with arbitrarily chosen time constants. The improvement in performance is subjective in character and therefore must be determined statistically by finding the reaction on a number of individuals.

The improvement offered by the compandor applies both to noise and crosstalk effects. The improvement can be allotted either to alleviate line exposure effects or it can be used to simplify the design of terminal equipment such as, for example, the filters in a carrier system.

As in any voice-operated device the improvement obtained is counterbalanced by the accompanying modification of the original signal. The technical problem includes the objective of obtaining the maximum improvement with a minimum of degradation. The present designs afford as much as 20- to 25-decibel improvement in signal-to-noise ratio, and are satisfactory for circuits carrying program music as well as for message circuits.

One form of the compandor has been standard in the Bell System for about ten years and is used in special cases on both voice and program toll circuits. Future applications of the compandor are concerned with short-haul cable and open-wire carrier circuits.

Limitations of Conductance Electrostatic Separators; *G. W. Penney (Carnegie Institute of Technology, Pittsburgh, Pa.), G. W. Hewitt (Westinghouse Research Laboratories, East Pittsburgh, Pa.).*

In conductance electrostatic separators, the variation in time rate of change of electric charge of particles on a conducting surface is used as a basis for separation. In the type of conductance separator used for the tests described, the particles are fed onto a rotating drum and electrically charged by corona. Low-resistivity particles lose their charge and are thrown off quickly, while high-resistivity particles remain on the drum longer. It is shown that for a given separator adjustment, the resistivity of one component must be significantly above, and that of the other component significantly below, a certain critical or dividing resistivity. For conductance separators, practical machine variations permit changing this critical or dividing resistivity only through a limited range. Particles are separated on the basis of size as well as of resistivity, so that only a limited range of sizes can be separated at any one time.

Technique of Handling Power System Problems on a Modern A-C Network Calculator; *P. O. Bobo (Westinghouse Electric Corporation, East Pittsburgh, Pa.).*

New techniques of procedure have been developed for the solution of problems by a-c network calculators. These, together with added improvements, have increased the efficiency of calculating boards by more than 50 per cent.

Methods of making the board generators' outputs almost self-regulating have been developed. The method utilizes the generator reactances set to values 30 to 40 times the ratio of megavolt-ampere base to megavolt-ampere desired output except for that of the so-called "swing machine" which is set at zero reactance.

The addition of varmeters to the complement of generator instruments and voltmeters to the load units give the board operator and power company engineer direct supervision of all generators and loads so that reactive distribution and voltages can quickly and easily be controlled. High-voltage circuits can be represented by equivalent pi-line elements permitting true line values to be measured at the circuit terminals. The taking of system data directly on system one-line-diagrams has been speeded by the use of special recording tables which indicate by lamp the exact spot for the recording of each data.

Methods of representing power system transformers using the board tap-changing-autotransformers have been worked out which remove all the confusion in computing "boost" or "buck" ratios and impedance data.

A new field of problems for calculating board solution has been opened just recently. It is the co-ordination of power system losses with fuel costs for determining plant loading schedules.[2] Algebraic loss formulas, which give losses in terms of the generation at each plant and flow in each interconnection, are first determined from I^2R losses derived from calculating board data.[1] These formulas are then converted into sets of equations for incremental transmission loss. The calculating board is then used to solve these equations combined with equations of incremental fuel cost for minimum values of delivered cost of energy.

Improper relay operations are occasionally the result of simultaneous fault conditions. We have therefore developed methods which simulate with calculator elements 120-degree transformations of the sequence connection diagrams[3] representing the various types of simultaneous unbalances.

Continual improvements in preparation, practices, and procedures, together with improved facilities of the modern boards, are definitely reducing the time requirements necessary for solving the expanding power system problems.

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Design Calculations for A-C Generators; *David Ginsberg (Engineer Research and Development Laboratories, Fort Belvoir, Va.).*

Tremendous strides have been made by the Armed Forces in the application of scientific weapons; this has created an urgent need for small lightweight mobile generating units having excellent wave form, voltage regulation, and transient response to suddenly applied loads. To aid in developing such units, it was necessary to make a new evaluation of design factors in order to determine how best to utilize recent discoveries in magnetic materials, insulation, and automatic regulating devices.

Previously published methods of calculating generator design and performance have not been applicable to generators with semi-enclosed slots or those employing small air gaps and high magnetic saturation. Generators of this type are necessary in order to achieve light weight. Moreover, calculations based on published curves for magnetic steel did not agree with test results on actual generators.

Accurate design calculations of generator steady-state and transient performance require a knowledge of two parameters of the no-load flux form in the air gap. These are the fundamental of the flux form "C_1," and the pole constant "C_p." The fundamental of the flux form is defined as the ratio of the peak flux density of the fundamental component of the no-load flux wave to the peak flux density of the resultant flux wave; and the pole constant is defined as the ratio of the average flux density of the no-load flux wave to the peak flux density of the resultant flux wave. Previously published curves for these parameters did not apply to generators having very small air gaps. Families of curves developed for these two parameters apply to the smallest air gaps. The theoretical formulas for these curves are somewhat complicated but they can be approximated with satisfactory accuracy by the following:

$$C_1 = 1.27\left(\frac{g_{\max}}{g_{\min}}\right)^{-0.35} \sin\left(90^\circ \frac{\text{Pole arc}}{\text{Pole pitch}}\right)$$

$$C_p = \left(\frac{g_{\max}}{g_{\min}}\right)^{-0.40}\left(\frac{\text{Pole arc}}{\text{Pole pitch}}\right)$$

where

$g_{\min}$ = Minimum radial length of air gap
$g_{\max}$ = Maximum radial length of air gap

Magnetization curves have been developed which take account of the flux distribution occurring in actual generators. The required magnetomotive force for obtaining a given maximum flux density on these curves ranges from one-third to three-quarters the magnetomotive force indicated for the corresponding flux densities on published curves for the steel. The higher the flux density, the smaller the ratio of required magnetomotive force to the theoretical value based on uniform flux distribution.

The method of calculation has been used to advantage on about 30 generators ranging in size from 3 kw to 100 kw and in frequency from 50 cycles to 400 cycles. The following general conclusions have been reached:

(*a*). Light weight can be achieved without sacrificing wave form or transient performance.

(*b*). Further reductions in weight and improvements in performance can be attained by judicious use of hiperco, silicone, and ceroc-teflon.

(*c*). Better slot insulating materials are needed to reduce space factors.

The Properties of Electrical Sheets for Rotating Machinery; *H. F. Shannon (Carnegie-Illinois Steel Corporation, Pittsburgh, Pa.).*

For many years the magnetic cores of rotating machines have been constructed of laminations punched from hot rolled silicon-steel sheets. Recently, however, the trend has been toward the use of material processed in continuous coils by the cold reduction

method. Experience has proved that this substitution of cold reduced for hot rolled sheets can be made without sacrificing any of the qualities desired in the completed machine. Additional evidence has been obtained which offers clues to explain the success of this substitution.

The results of core loss and permeability tests made on comparable samples of hot rolled and cold reduced sheets in the grades and gauges most commonly used for rotating machinery indicate that the magnetic properties of the two products are the same for all practical purposes.

Torque magnetometer and directional core loss tests show that both hot rolled and cold reduced sheets are isotropic in nature; that is, their magnetic properties are practically the same in all directions. Such isotropy or randomness of magnetic properties is necessary in sheets used for rotating machines wherein the flux path is continually changing direction in relation to the rolling direction of the sheets.

The surface scale on the cold reduced product is generally thinner, less abrasive, and more tightly adherent than that on hot rolled sheets. The insulating properties of the scales on the two materials, however, are approximately the same. The thinness of the scale is reflected in the results of lamination factor tests and the insulating properties are indicated by the results of interlamination resistance tests which were made on comparable samples.

The experiences of many manufacturers have amply demonstrated that cold reduced sheets have better punching properties than do hot rolled sheets. Part of this superiority is attributed to the good surface condition of the cold reduced product, and part is attributed to the fact that the mechanical properties of this product are conducive to good punchability. No correlation has been established between mechanical properties and punchability, but it has been suggested that a high yield/tensile ratio, such as possessed by cold reduced silicon steel sheets, is indicative of good punching properties.

Suggested Standards for Electric Power Supplies Used in Electrostatic Precipitation; *H. V. Nelson (General Electric Company).*

The greatly expanding use of electrostatic precipitation has made desirable a common understanding of the terms used in this field. As a preliminary framework on which an exact set of Standards can be built the definitions and Standards suggested are offered for consideration.

"American Standard Definitions of Electrical Terms," C42-1941, are suggested for use where possible and modifications of these terms are suggested when the standard terms are not sufficiently specific. Symbols, fundamental terms and derivatives, standard electric equipment, and common electrical phenomena as defined in American Standards Association C42-1941 are suggested for use without modifications. Rectifier circuits as defined in the proposed Standards of the AIEE Subcommittee on Hot-Cathode Power Converters and new definitions where these do not suffice are suggested to define such rectifier circuits as single and double way, half-wave and full-wave (diametric), bridge (diametric double-way), and voltage doubler. Similarly, definitions are recommended for mechanical, vacuum tube, and metallic types of rectifiers. Suggested definitions are also included for current-limiting and protective circuits as well as terms defining the rating of electric power supplies.

Suggested nameplate data would include a complete description of the input power required and the output d-c average volts and amperes continuous rating. Where the rectifier and its transformer form an integral unit it is suggested the rectifier nameplate data be combined with that for the transformer.

In testing a precipitator power supply it is recommended that the input be read by rms meters, output current by milliameter, and output voltage by a milliameter used with a resistance multiplier. Ripple ratio is to be determined using an oscillograph in conjunction with a resistance divider on a capacitance divider. A noninductive resistance load should be used as a test load.

In general, "American Standards for Transformers, Regulators, and Reactors" are recommended as Standards for transformers used in precipitator supplies. Standard commercial electrical tests will include resistance, ratio, no-load loss, impedance, applied potential, and induced voltage tests.

It is hoped that these suggested Standards will promote considerable discussion and that the constructive criticisms and suggested revisions obtained from members of the committee and interested people outside the committee can be incorporated into a set of useful Standards which will contribute to the growth of this field.

Electrocoating; *J. O. Amstutz (Behr-Manning Corporation, Troy, N. Y.).*

The manufacturing of coated abrasives has grown from a relatively simple process of coating a sheet of paper with glue and grain into a highly technical business. Today the paper and cloth used as backing is of special construction. The adhesives are special scientific formulations, and the grain is prepared for sharpness, accurate grading, and toughness. Coated abrasives are precision and high production tools which are used in an unlimited number of industrial applications.

Since the earliest days of sandpaper making, it was recognized that the position of the sharp-edged and sharp-pointed grain was an important factor in the making of clean cutting, longer lasting, and better performing coated abrasives. What is commonly called sandpaper or emery cloth is known to the professional user as coated abrasives including all classes of abrasive paper and cloth such as flint, garnet, aluminum oxide, silicon carbide, and emery.

In the past, many methods have been tried to orient grain on the backing in such a way that the sharpest cutting edges and the sharpest points of the grain were turned out exposing them for most effective cutting. No method does this job of grain orientation better than the electrocoating method. Electrocoating, a patented process, is a perfect method of grain handling whereby each and every individual particle is under definite control in regard to dispersion, orientation, alignment, and deposition. Under the influence of electrostatic field forces, particles are separated from each other, dispersed, and evenly spaced. They are lined up in the direction of the electrostatic field and deposited perpendicularly onto the backing. It is in this positive control of each particle that the principle difference is found between electrocoating and any other coating method. With electrostatic deposition of grain in the most favorable position, evenly spaced, held upright by the adhesive, with the sharpest edges or points turned out, a product is created which cuts faster, cleaner, and freer, and which results in greatly increased production.

After the electrostatic coating method for sandpaper was well established, it was discovered that the same process can be used for the manufacturing of electrotextiles. Instead of using grain, as in coated abrasives, fibers of wool, rayon, cotton, and cattle hair are deposited electrostatically in an upright position onto cloth fabrics and held in that position by suitable adhesives. Many velvet-like textile fabrics can thus be made, such as ladies' dress goods, automobile and upholstery fabrics, pocketbook and shoe materials, decorative fabrics, draperies, curtains, rugs, and carpets. Suedelike shoe materials are made to replace leather and beautiful ladies' dress goods are coated in pattern form simulating embroidery. The fibers used for producing textile fabrics must be prepared for physical and electrical characteristics, and only after they are rendered susceptible to the electrostatic field forces can they be deposited onto a backing by means of a high-intensity electrostatic field. Electrocoated textile fabrics are dense, fluffy, and deep. Densities from 250 to 300,000 fibers per square inch are obtained, with rayon fibers of 3.5 denier. No woven fabric can be made as dense as that, one of the reasons why electrocoated fabrics outwear the woven ones by a surprisingly large margin. The adhesives used in electrocoating are difficult to manufacture.

Electrocoated fabrics are produced for industries which have set up extremely severe specifications. Adhesives for dress goods, for instance, must be flexible. They must stand dry cleaning, washing, and ironing. Adhesives which meet such requirements are specialties; they are made to order and can only be produced and applied after extensive research and long practical experience. Each coating application presents its own adhesive, fiber, and backing problem which must be solved in order to produce a satisfactory product. Shoe material must wear as well as leather, and millions of shoes are made yearly with an electrocoated fabric known as Norzon, manufactured by the Behr-Manning Corporation in Troy. Many new applications in the field of textile fabrics and other lines are constantly turning up where the electrocoating process can be used, for instance, gramophone turntables, jewelry boxes, suede jackets, velvet ribbons, window channels, and other applications by far too numerous to mention.

Frequency Assignment Plan for the Railroad Radio Service; *L. E. Kearney (Association of American Railroads, New York, N. Y.).*

In formulating a plan for assigning radio frequencies for the use of individual railroads, it was necessary first to determine the manner in which radio communication would be applied to railroad operation. Fortunately, a report of the railroad committee of the Radio Technical Planning Board embodying such information had been prepared for Federal Communications Commission hear-

ings in 1944 and 1945 and this formed the basis on which radio assignments were made. A questionnaire submitted to railroads in 1945 developed information as to the probable frequency requirements of each of the railroads responding.

Chicago, as the railroad hub of the United States, became the keystone of the assignment plan. Frequencies were assigned for train service of all railroads in that area which had expressed a desire to be included in the plan. Since some rolling stock of a railroad may operate on all parts of its system it is necessary for simplicity and efficiency of operation that the same frequency be assigned for use on the entire railroad. Thus, the assignments made at Chicago fixed part of the assignment plan for those areas of the United States reached by the Chicago railroads.

To facilitate formulation of a nationwide assignment plan the United States was divided into six districts, namely, New England, Northeast, Pocahontas and Southern, Northwest, Central West, and West and Southwest. A plan for each district or natural subdivisions thereof, such as a state, a group of states, or a large railroad terminal, was prepared, each one being dovetailed with the plans for other areas.

After frequency assignments for train or mainline operations had been completed, assignments for local operations such as yards and terminals were made, to the extent to which frequencies were available.

The completed plan after approval by the railroads was filed with Federal Communications Commission by the Association of American Railroads as a recommendation for frequency assignments to individual railroads. Minor modifications of the plan are made from time to time as further developments in the railroad radio service require such changes.

The Brookhaven 2.5-Billion-Volt Proton Synchrotron; *Milton G. White (Palmer Physical Laboratory, Princeton University, Princeton, N. J.).*

A number of design problems have been and are being encountered in the development of a 2.5-billion-electron-volt proton accelerator of the synchrotron type. Chief among these is the variable magnetic guide field which keeps the protons travelling in an orbit 75 feet in diameter. To produce stable orbits, it is necessary that the magnetic field have a definitely prescribed radial variation in the region 300–14,000 gauss. Effects which were found to distort the field shape were radial variation of remanent field, eddy currents in the one-half-inch plate lamination of the magnet, and nonuniform saturation of the iron. Means for correcting or allowing for these perturbations have been worked out. The magnet peak power consumption will be approximately 6,000 amperes at 5,000 volts and will be drawn from a large flywheel through a 12-phase alternator and ignitron rectifier set. Energy stored in the magnet at the peak of its excitation will be returned to the flywheel by changing the phase of the ignitron firing circuits to operate as an inverter.

The accelerating radio-frequency electric field must vary in frequency from about 0.3 megacycle to 4.0 megacycles during the one-second interval when the protons are speeding up from the injected energy of 3–4 million electron volts to the final 2.5-billion electron volts. A special radio-frequency transformer made of one ton of ferromagnetic ceramic material has been designed and tested in part. An untuned video amplifier with a 50-kw output has been designed to drive the transformer. The radio frequency must increase with the magnetic field in a very precise manner determined by a computing circuit which converts a signal proportional to the magnetic field into the proper frequency control voltage.

A problem of considerable novelty is the 75-foot diameter vacuum "donut" which must be pumped to a vacuum of better than 10^{-5} millimeter of mercury. Heavy metal walls cannot be used because the rapidly varying magnetic field would induce disturbing eddy currents. A combination of plastic sheets and 2-mil inconel sheets will be built up into a chamber 40 inches by 8 inches by 230 feet which is to be evacuated by 12 20-inch oil diffusion pumps.

Completion of the heavy engineering phase is scheduled for Summer, 1950.

Equipment for Uranium Prospecting; *Frank W. Stead (United States Department of the Interior, Geological Survey, Washington, D. C.).*

Equipment for uranium prospecting, now in use or under development by the United States Geological Survey, falls into three groups: surface, subsurface, and air-borne. Most of the equipment is commercially available, modified to meet particular field requirements.

Surface prospecting on foot is performed with portable survey meters of the health physics type. The meters are usually modified by substituting a probe containing four to six large Geiger counters, thus increasing the counting rate to permit more rapid measurements. To increase the speed of prospecting, 42-inch Geiger tubes in parallel are installed in automobiles; counting-rate meters with short-time constants record the radiation intensity. In favorable terrain and with suitable vehicles, such equipment has been used in off-the-road prospecting.

Subsurface prospecting is essentially restricted to gamma-ray logging of exploratory drill holes. Truck-mounted logging units have been developed to measure the radioactivity in diamond-drill holes as small as $1^1/_4$ inches in diameter; several such units are operated on the Colorado Plateau to provide guidance in the search for carnotite ores. Auxiliary equipment for subsurface prospecting includes a core-logging unit that can automatically measure the radioactivity of several hundred feet of rock core per day.

Air-borne prospecting for uranium, now in the experimental stage, incorporates the previously developed techniques of aeromagnetic surveying. Anticoincidence counting-rate meters and an air-conductivity meter are used to detect radiation; these meters are synchronized with a continuous-strip camera and a radar altimeter, thus permitting the exact 3-dimensional location of an air-borne measurement.

For the average prospector, the Geiger counter is a highly useful tool, as it detects uranium not immediately identifiable by visual inspection. The simple, cheap models providing only earphones are satisfactory for the average prospector; the more complex, expensive models are more suitable for geologists and engineers in evaluating ore deposits.

Control Problems of a Power Producing Nuclear Reactor; *J. M. Harrer (Argonne National Laboratory, Chicago, Ill.).*

To convert the heat released in fission in a nuclear reactor into steam power economically, the reactor must be operated at temperatures of 500 degrees Fahrenheit or more. The rate of heat generation must be controlled to provide a reliable power source and, at the same time, to prevent damage to the reactor and operating personnel.

A thermal neutron reactor is controlled by increasing or decreasing the amount of neutron absorbing material, such as boron or cadmium, in the active core. These materials are inserted in the form of rods. In power-producing reactors the elevated temperature necessitates a pressure enclosure and the motivating drives for these rods must work through this enclosure or immersed in the coolant, which might be gas, water, or liquid metal.

Neutron density is a measure of the power, and instruments, which will operate under the conditions of elevated pressure and temperature, are difficult to build. Stabilizing the neutron density in a power-producing reactor will require accurate and rapid instrumentation, especially if rapid changes in reactivity can occur. A reactor in which the net or effective number of neutrons produced for each neutron absorbed in fission is greater than one is said to be supercritical. In this condition the neutron density can increase very rapidly since a neutron is absorbed on the average every 1/1,000 of a second.

To prevent dangerously high neutron densities, the control system must include control rods which can be inserted rapidly in case the neutron density approaches design limits. Neutron density excursions great enough to trip such a safety system must be kept to a minimum if reliable power production is to be realized. This can be accomplished by providing an automatically controlled rod capable of rapid movement but with limited reactivity so that any neutron density excursion away from the desired power is quickly returned to the control level. Such an automatic system can be devised using established servomechanism design techniques.

Cleanup of a Noble Gas in an Arc Discharge; *M. Redden (National Bureau of Standards, Washington, D. C.).*

Electron tubes filled with a noble gas such as argon, neon, or helium are now widely used in many engineering applications. However, their use is prohibited in many additional applications by a gradual reduction in pressure of the filler gas with use. The cleanup effect is generally considered to result from the bombardment of negatively charged electrodes by ions populating the discharge.

The present work represents an effort to study cleanup under controlled laboratory conditions, and it is hoped that at its conclusion it will furnish tube designers a basis for choosing the best combination of structural materials for maximum tube life in a given application.

A specially designed helium-filled discharge tube having a replaceable tantalum probe wire was employed to collect the positive ions. Experimental techniques were followed which avoided any risk of contamination by foreign gases or vapors and which permitted accurate measurements of pressure conditions.

A slow reduction in pressure is observed even with electron current being collected by the probe wire. This has been designated as "self"-cleanup. It has been found that self-cleanup is apparently dependent on a few volts variation in arc drop. In successive tubes having arc drops ranging from 52 to 74 volts, the self-cleanup rate varied by about a factor of 100. At about 60 volts arc drop, the rate is approximately 0.05 micron per minute per ampere arc current in a 1.5-liter system. Test runs were made with various negative voltages on the probe wire. The results were corrected for self-cleanup and electron emission from the probe due to ion impact. There is a clear dependence of rate of cleanup on the negative probe voltage. There is an indication also that the rate of probe cleanup is influenced by the ratio of ion sheath thickness around the probe to the ionic mean free path. At a negative probe potential of 500 volts, approximately seven ions are cleaned up for each 1,000 ions striking the probe wire.

Commutation Factor Rating of Inert Gas Thyratrons and Its Influence on Circuit Design; *D. E. Marshall, C. L. Shackelford (Westinghouse Electric Corporation, Bloomfield, N. J.).*

The commutation factor rating of an inert gas-filled thyratron specifies to the circuit designer the capability of the tube to withstand positive ion anode bombardment. It also enables proper circuit constants to be determined so that bombardment is limited to a degree allowing reasonable tube life.

The commutation factor, η, is empirical and is expressed as the product of the rate of change of anode current immediately before commutation and the rate of change of voltage across the tube immediately after commutation and is given in ampere-volts per microsecond squared.

If the measured commutation factor of a rectifier at its greatest grid retard angle is greater than the commutation factor rating of the tubes employed, it is necessary to adjust the circuit to the rated commutation factor by paralleling the tubes with cushioning circuits consisting of a capacitor, C, in series with a resistor, R. The values of R and C are proportioned with the leakage inductance per anode, L, so that a critically damped transient response is obtained. Any departure from critical damping should be toward the overdamped condition.

The required resistance is

$$R=(4\eta L^2/E_{tt})10^{12} \text{ ohms}$$

where E_{tt} is the commutating voltage. For critical damping

$$C=8L/R^2 \text{ farads}$$

and should be no smaller. These values should be determined for the maximum E_{tt}; that is, the maximum grid retard angle at which the rectifier must operate.

The current in the cushioning circuit consists of a steady-state component and a repeated transient. The power loss is due principally to the latter. At each discontinuity in the voltage wave form the power $1/2C(\Delta E)^2$ will be lost in the resistor; therefore, the smaller the capacitor required, the less the power loss in the cushioning circuit. It can be shown that the size of the capacitor varies inversely as the square of the commutation factor, directly as the cube of the frequency, and, for a given per cent regulation, directly as the cube of the *VA* rating of the transformer. Thus, losses in the cushioning circuit increase rapidly with the size of the rectifier.

Registration of the Young Engineer; *H. L. Solberg (Purdue University), J. H. Foote (Commonwealth Services, Inc., Jackson, Mich.).*

This paper is an amplification of a report prepared in October 1949 by Professor Solberg for the Committee on Professional Training of the Engineers' Council for Professional Development. The authors review the history and growth of professional engineering registration in the United States and point out that professional registration of the engineer has become an accomplished fact widely recognized and accepted throughout the United States, as attested by the approximately 150,000 registrations in effect at the beginning of this half-century.

The giving of a degree of professional status to young engineers who have passed prescribed examinations and have been certified as "engineers in training" has publicized the matter of professional registration and has emphasized the significance of professional status to larger numbers of engineering graduates than ever before. Even more significantly it has brought to his attention the importance of being employed at types of work which are such as to utilize his engineering education and to develop and broaden his engineering viewpoint and experience.

The attitude of industry toward professional registration varies widely, and there undoubtedly is need for sympathetic understanding by employers of the legal requirements as well as the value to them of encouraging their engineering employees to establish professional status.

A 3-point program which can be advanced effectively by engineering societies through their local sections would: provide the young engineer with reliable information concerning the requirements and procedures for registration in the state of his residence; provide refresher courses in those states in which examinations are required for registration of the engineering college graduate; and provide information and counsel which will assist him to develop a professional engineering viewpoint and understanding of the problems which derive from his daily work.

Self-Appraisal for Orientation to the Profession; *Allan R. Cullimore (Newark College of Engineering, Newark, N. J.).*

Statement of the Problem. It has been generally recognized by engineering educators and by other groups interested in the development of young engineering graduates that the first few years after graduation are very critical years. Many a young man finds that he is retained as a technician rather than as a professional man.

He fails to realize that professional activity and professional relationships depend upon something more basic than brains or mere technical competency, that he must possess certain qualities of personality and of character to insure professional recognition.

The Suggested Solution. The suggestion is made, therefore, that, at the end of two or three or four years as the case may be, the young man be stimulated to take stock of himself. It is believed this project should be divided into three rather distinct phases. First, he must appraise his own training in the light of his past experience. Second, he must get some appreciation of those personal characteristics which best fit the proposed pattern of the work which he hopes to undertake. Third, he must find out, if possible, the characteristics and requirements in fields which touch, but lie outside, his present line of endeavor so that he may reorient himself with respect to his profession.

He may, after all, decide to remain in that functional division of the broad field of engineering in which he now is. In any case, a reappraisal within a reasonable time after graduation would serve to point the way to a very much richer and fuller professional training.

Aids to the Solution. There are at hand certain aids to this program of self-appraisal. The Engineers' Council for Professional Development has had available for a number of years a personal appraisal form which would seem to be admirably adapted for use in the first part of this program. It is up to date in that it reflects, although of some antiquity (12 years), the best thought at the present moment, and serves as a summary of the conclusions to which the young man has come on the basis of his short, but illuminating experience.

The personal appraisal form, however, has to do *primarily* with matters technical, so that, in order to implement the second part of the program, it should be supplemented by a publication compiled by Dr. Cullimore and Professor Entwisle entitled "The Most Desirable Personal Characteristics." This pamphlet contains an inventory of personal characteristics which should prove extremely valuable to the young man in his attempt to rank the qualities which he *thinks* are necessary in the job which he has in mind. His reactions can then be checked against the reactions developed in curves reported in the latter part of the pamphlet, which summarizes the opinions of a number of high-placed executives and personnel officers.

Further assistance for his program comes from another source. The Bureau of Labor Statistics is shortly to publish a book which compares the work of engineers in various fields, gives something of the migration from one field to another, and has certain tables which give possible earnings in various engineering fields. It should be required reading for every young engineer. Better than any other known publication, it will give the young engineer some detailed knowledge of what the future holds along the lines of a possible choice.

Integrating the Young Engineer Into His Community; *K. B. McEachron, Jr. (General Electric Company, Schenectady, N. Y.).*

Why should we be concerned with the associations between young engineers and their communities when the engineering group represents such a small fraction of the membership of most communities? Why should engineers, whose principal interest is in the design, production, and sale of products and services, be concerned, any more than any one else, with such community problems as a public school education, city planning, and public works?

Whether right or wrong, engineers are considered to be more objective in their approach to any problem than the average citizen and to have an ability to organize facts and information to arrive at the most desirable conclusion with less prejudice and personal bias than most. The additional education and training, beyond the average, which engineering graduates have enjoyed, places upon them an obligation to use the benefits of such education in the public interest. We are particularly concerned with integrating the young engineer into his community because we can no longer afford to wait for chance or accident to make available to each local community the information and knowledge which the engineer can contribute to the solution of community problems.

No one group, industry, community, or individual engineer can be assigned the sole responsibility for helping the young engineer find a place in the community where he can perform a worth-while service. Each has a contribution to make which is unique. Where these four work together as a team with the common objective of community improvement in all areas, even the most difficult problem will not prove impossible of solution.

What has been accomplished in particular communities where either industry, the community, or the individual engineer has taken the initiative and developed an organized program for discussion and action seems almost impossible to believe. Such specific cases illustrate the benefits to all concerned of an organized program to develop the community relationships of young engineers fully as rapidly as their company and industrial associations. In past years industry has seldom considered community problems to be of major concern. It is now beginning to realize that its very existence and, therefore the material well-being of everyone, is going to be more directly affected by how successfully each community solves its problems than by how effective a production, or even an employee relations job, industry does within its factories.

Although the integration of the young engineer into the community is not limited to its economic and political aspects, these have assumed such a magnitude and urgency that in any consideration of the problem they deserve first attention else we may lose the opportunity and freedom to contribute effectively to any other community problems.

The Keystone Pipe Line Microwave Link; *Edwin B. Dunn (Keystone Pipe Line Company), Anthony J. Finocchi (Federal Telecommunication Laboratories, Inc.).*

A continuous, unattended microwave telephone link has been installed between Philadelphia and Montello Pumping Station by the Keystone Pipe Line Company, subsidiary of Atlantic Refining Company. This link, representing the first application of microwave communications to the pipe-line industry, operates in the frequency range of 1,850 to 1,990 megacycles and provides up to 23 voice channels. In the initial installation only five voice and five signaling channels are used, but additional channels can readily be supplied as required.

The microwave link, manufactured by Federal Telephone and Radio Corporation, was selected on the basis of economy and reliability. This equipment was developed by the Federal Telecommunication Laboratories, Inc., research unit of International Telephone and Telegraph Corporation. Communications are a vital factor in the operation of pipe lines and it is extremely important that reliable dispatching service be provided, particularly during periods of adverse weather conditions. An examination of the systems of communication available revealed that the Federal equipment would meet the demands of reliability and continuity of service required at a cost comparable or below an equivalent wire line method.

Communication facilities were required between the Philadelphia office of Atlantic Refining Company and the Montello Pumping Station, a distance of 60 miles. At these two terminal points the link ties into existing telephone lines. A drop channel point was necessary to provide facilities to the Boot Pumping Station which is located about halfway between Philadelphia and Montello.

In order to install the radio link, line-of-sight paths were required between the terminals involved. The problem of site selection must be considered not only from the viewpoint of the propagation of microwaves; but also from the viewpoint of economy, availability of land, availability of power, and access roads to sites.

In this system, two repeater points are used. Two repeater points, rather than one which is normally considered sufficient for a path of this length, were required for the following reasons:

1. The two pumping stations; that is, Boot and Montello, are located in valleys thereby making line-of-sight contact difficult.

2. Sites were also selected on the basis of the possibility that the link may be extended beyond Montello—thus the Deer Path Hill repeater was selected with a view to using it as a starting point for an extension of the link.

Description of the Equipment. The link employs the pulse-time multiplex method of modulating and multiplexing, thereby enabling the transmission of 23 audio channels on one carrier frequency. Since the pulse-time multiplex method of modulation is inherently capable of transmitting low-frequency and d-c signals, and since the audio bandwidth is 200 to 3,400 cycles, the frequency range below 50 cycles is available for signaling and dialing purposes. As a result, the link contains one low-frequency path for each voice channel used and is readily adaptable to any dialing or signaling system. In this case both 20-cycle and 3.5-cycle signaling circuits are provided.

In a typical repeater site two transmitters, two receivers, and two power supplies are used, and all are easily contained within one standard 7-foot relay rack. Both transmitter and receiver employ microwave triode oscillators, thereby effecting extremely simple and compact radio-frequency equipment.

Mechanism of the Electric Spark; *L. H. Fisher (New York University, New York, N. Y.).*

In the Townsend mechanism of the spark, the current in the gap becomes self-sustaining by secondary emission of electrons by positive ion bombardment of the cathode. According to the recently developed concept of the breakdown by the streamer mechanism,[1] the streamer is a process whereby the gap is bridged by a positive ion space charge without the motion of positive ions. The process occurs with the aid of photoelectric ionization in the gas. The Townsend mechanism requires a time to develop which is of the order of the positive ion transit time across the gap (about 20 microseconds at atmospheric pressure and gap separation of one centimeter.) The streamer occurs in a much shorter time (a tenth of a microsecond or less), since only the motion of electrons and photons are involved.

The present view of the mechanism of the spark discharge in air is that the streamer mechanism is effective in the neighborhood of atmospheric pressure and that the Townsend mechanism applies at much lower pressures. (A Townsend mechanism of secondary electron emission by photoelectric action at the cathode is not generally thought to be active in air and is not considered here.) Experimental values of the sparking potential cannot at present be used to distinguish between the two mechanisms.

REFERENCE

1. The Mechanism of the Electric Spark, **L. B. Loeb, J. M. Meek.** Stanford University Press, 1941.

"Unionmelt" Voltage Controls; *J. A. Kratz (Linde Air Products Company, New York, N. Y.).*

One of the most attractive features of submerged melt welding is the fact that extremely large welding currents can be used, and, thus, it makes possible the welding of heavy plates in one pass.

In order to take advantage of this feature, however, it was necessary to design new welding equipment and controls which could handle currents up to 4,000 amperes and welding rod up to one-half inch diameter. Furthermore, since the operator cannot see what is going on in the welding zone, controls for the welding action have to be as automatic as possible, and meters have to be provided so that the operator can adjust the settings if necessary.

As "Unionmelt"* welding began to be used for lighter weldments, lighter portable machines were developed which could be more easily operated and maintained. With the lighter units came simplified, lighter controls, until at present there are three different controls and associated equipment. These are the electronic, the series, and the air-control units. All of these controls use the arc voltage to regulate the speed of the rod-feed motor and thus maintain the welding voltage at a constant set value.

The electronic control uses the welding voltage to control two thyratron tubes, the output of which is applied to the rod-feed motor. The series control applies the welding voltage directly to the armature of the feed motor. The air control uses the welding voltage to control a solenoid-operated air valve which, in turn, controls the speed of the air-driven rod-feed motor.

Various refinements and other circuits have been added to these basic control systems so that the operator can make all necessary adjustments from one station, usually near the welding head. The series control and the air control are effective in keeping the welding voltage within plus or minus one volt of the set value. With the electronic control it is possible to obtain operation within plus or minus one-half volt of the set value. In judging the effectiveness of the control unit, the sole criterion is its ability to make smooth, uniform, deeply-penetrated welds.

* Trade-mark, The Linde Air Products Company.

Submerged Arc Welding Control Circuits; *L. K. Stringham, Emmett Smith (The Lincoln Electric Company, Cleveland, Ohio).*

During the past several years a great deal of work has been done to develop automatic arc welding control circuits which are as simple as possible and which perform with the necessary precision and accuracy that dependable welds can be made without any special skill of the welding operator.

Submerged arc welding is a metal arc process which employs a granular flux with a bare wire electrode. The arc voltages are about the same as hand welding, but the current densities, and likewise the melting rates, are up to four or more times greater than hand welding.

In order to produce sound dependable welds, the control circuit must provide the means to establish the welding arc quickly and maintain the welding voltage at some predetermined value. Electrode melting rates are usually from 20 to 125 inches per minute and the control circuit should be able to feed the electrode over this range without making gear changes, motor changes, or any change which might present other problems in the over-all operation of the equipment.

A very simple circuit for d-c welding consists of a shunt motor, separately excited, with a rheostat in series with the armature. This combination is connected across the arc voltage so a part of the arc voltage is impressed on the motor armature. Any change in the arc voltage changes the motor speed which, in turn, changes the rate of electrode feed. For a-c welding, the circuit is essentially the same except that the motor is a series motor. However, the control is less accurate due to the characteristics of a series motor.

Where the automatic equipment is required to operate with great accuracy over a broad range of current and electrode sizes, a more versatile control than the afore-mentioned one is necessary. A circuit which meets these requirements for d-c welding consists of a shunt motor, separately excited, and a control exciter, separately excited. The armatures are connected in series and the combination connected across the arc voltage in such a manner so the sum of the motor and exciter voltages is equal to the arc voltage. A change in the arc voltage is amplified to the motor armature without electronic devices. This circuit retracts the electrode to establish the arc and is readily adapted to high-speed production work so frequently necessary, such as in the automotive industry. The arc voltage is controlled with sufficient accuracy to make possible welding of thin sheets at welding speeds in excess of 100 inches per minute.

The two circuits described make use of equipment which is readily understood by maintenance employees and is easily serviced. One circuit is extremely simple and is satisfactory for a large percentage of welding applications. The other circuit employs more equipment but retains simplicity and is used where precise arc voltage control and versatility are necessary.

The Operating Time of D-C Magnet Brakes; *J. E. Ryan (General Electric Company, Schenectady, N. Y.).*

Fast, accurate load positioning in hoist and similar applications requires rapid pickup and drop-out time of magnet brakes. Since pickup is usually slowest on shunt brakes, this subject is treated in the present paper; the subject of dropout behavior will be covered in a later one.

Using standard methods, an expression for the instantaneous torque is derived in terms of a characteristic magnet dimension and a number of constants dependent upon the magnet proportions. The brake shoe load is related to the ultimate magnet torque by a parameter which may be varied at will. Finally, the time for the flux to reach the pickup value is expressed in dimensionless form as:

$$\frac{\delta r t_1}{l D^2}=\left[\frac{rW}{ahl\alpha^2 D^4}+1\right] ln \left[\frac{1}{1-\frac{\alpha}{\gamma}}\right]$$

where

t_1 = Time to start armature motion.
D = Characteristic magnet dimension.
W = Work done on brake shoes.
α = Fraction of full excitation required for pickup.
γ = Fraction of full excitation applied.
a, h, l, r, δ = Constants.

This is plotted with $\frac{\delta r t_1}{lD^2}$ as ordinate, $\frac{rW}{\alpha h l \alpha^2 D^4}$ as abscissa, and α as parameter. An optimum envelope curve is then drawn as a design criterion. Only magnets having the same proportions may be compared at one time, using the plot; nevertheless, some basic conclusions may be drawn:

1. For a given W, t_1 decreases steadily as D increases.
2. If D is made proportional to $\sqrt[4]{W}$, t_1 will be proportional to $\sqrt{W}$.
3. t_1 is inversely proportional to total coil circuit resistance, other factors remaining the same.
4. A given amount of work can be performed faster with two magnets than with a single one having the same total volume.

The analysis applies equally well to any shunt electromagnet unsaturated in the open-gap position.

Basis of Rating a Plate Rheostat; *L. J. Parkinson (General Electric Company, Schenectady, N. Y.).*

Devices are designed with certain objectives as to ratings in mind. The ratings actually obtained when the design of the device is completed become limiting factors in its application. In the case of a plate rheostat two of these factors are maximum watts that can be dissipated continuously and maximum summation watts.

The heat dissipating ability of the rheostat plate design determines the watt dissipating ability. Temperature limits specified by the Underwriters' Laboratories and maximum operating temperatures of component parts limit the watts that can be dissipated.

The summation watt rating of a rheostat is the product of its maximum current rating, minimum current rating, and the rheostat resistance. This rating, while not a rating of dissipation, is a yardstick or standard which is dependent upon the individual watt rating of each unit or step in the plate.

From the summation watt rating the maximum watts that will be dissipated by the rheostat in a series circuit can be determined from the following equation:

$$W_{\max}=\frac{C}{4(C-1)}\Sigma W$$

where

C = Current taper = $\frac{\text{Max Current}}{\text{Min Current}}$
ΣW = Summation watt rating

From a better understanding of how the rating is established more efficient use is made of the rheostat, resulting in savings both to the manufacturer and the user.

A 5-Kw Iron-Core-Coupled Radio Transmitter; *L. F. Deise, L. W. Gregory (Westinghouse Electric Corporation, Baltimore, Md.).*

Radio transmitters designed to operate in the low- and medium-frequency ranges normally utilize parallel resonance tuned L and C components as "tank" circuits for the amplifier stages. These conventional amplifier "tank" circuits impose several problems in the design of transmitters for operation, by instantaneous selection, on two or more frequencies and where transmitter physical size is limited.

One novel solution to the problems is the use of an untuned high-frequency iron-core transformer as the output circuit of a class-B push-pull power-amplifier stage, and the use of untuned transformers and reactors as output circuits in the preceding stages of the transmitter. This solution was successfully used in the design of a 5-kw multifrequency communication transmitter for operation between 250 and 540 kc.

The iron-core transformer used in the power amplifier stage of this design couples the output of the push-pull power-amplifier tubes to an unbalanced 51.5-ohm load. This transformer is 8 inches high and weighs 11 pounds. The transformer core is made of 0.002-inch thick "Hipersil" grain-oriented steel. The windings are arranged in core-type construction and interleaved in such a manner as to give the same performance on both halves of the primary. Impregnation with "Fosterite" solventless varnish is used to provide adequate insulation in small space and to protect the windings from moisture.

An untuned high-frequency iron-core autotransformer is used to match the 51.5-ohm secondary impedance of the output transformer to antenna impedances between 3 and 20 ohms. By means of links on the autotransformer any impedance between 3 and 20 ohms can be matched within five per cent.

The use of high-frequency iron-core transformers as output circuits for the power amplifier and preceding stages of a transmitter eliminates circuit tuning and greatly reduces the transmitter's physical size. The elimination of circuit tuning, by iron-core transformer coupling, provides the simplest design for multifrequency operation.

Primary Batteries; *C. H. Clark (Signal Corps Engineering Laboratories).*

The tremendous advances in the field of military and commercial electronics during and since World War II have necessitated corresponding advances in the field of portable power supplies. The requirements of these equipments, coupled with the unusual

climatic conditions encountered under the military worldwide scope of operation, made it essential that existing prewar types of primary batteries be improved to meet these demands. Through the efforts of the Signal Corps Engineering Laboratories, several universities, and numerous commercial organizations, primary batteries have been designed and constructed which meet many of these military requirements.

The Leclanche battery (zinc-ammonium chloride-manganese dioxide system) has been improved to that point wherein it now gives increased capacities over the temperature range of −65 to 70 degrees Fahrenheit and higher. It is better able to withstand storage under tropical climatic conditions. Successful attempts have been made to develop improved quality cell components in order to relieve the raw material supply situation.

An alkaline dry battery (zinc-potassium hydroxide-mercuric oxide system) has been designed which is a considerable improvement over the Leclanche system from a capacity per unit of weight and volume standpoint. The presently designed cell has been improved to that point where it is much more reliable after long storage periods than was the wartime (R-M) cell.

Miniaturization of both of these battery types is of critical importance as a result of the recent trends in military equipment designs. Investigations pertaining to this matter are underway, with considerable promise being shown by several designs.

The critical nature of the zinc supply in the United States made it essential that a substitute be found for zinc as a battery anode material. Magnesium has proved to be not only a successful substitute, but also an improvement over zinc in many respects. Magnesium dry cells have been developed that give initial capacities at least double those of corresponding size zinc cells under the same test conditions. Delayed capacity characteristics of these magnesium cells also appear promising.

Although tremendous gains in each of the three previously mentioned cell systems have resulted from battery research and developments made during the past few years, continued research and development is still necessary to provide a military battery to meet existing requirements. This program is underway under the supervision and cognizance of the Signal Corps Engineering Laboratories.

Military Storage Batteries; *H. J. Mandell* (*Signal Corps Engineering Laboratories*).

The operation of military storage batteries, both lead-acid and nickel-cadmium, at all temperatures, especially at subzero temperatures, has been greatly advanced during recent years. This has been effected through the combined efforts of industry, the universities, and other research and development organizations, under the direction of the Signal Corps Engineering Laboratories.

The improvements in the low-temperature performance of the lead-acid battery affected primarily the high-rate low-temperature discharge characteristics. These improvements resulted from changes in battery design, mix formulation, and operating procedure, and from fundamental studies of the reactions occurring in the battery at normal temperatures and at subzero temperatures as low as −65 degrees Fahrenheit.

Design and mix formulation changes included the construction of thin walled battery cases to increase the internal volume (for a 2H size battery this increase is 15 per cent), the dispersion of the active materials in an increased number of thinner plates to increase surface area and reduce current densities, the use of thinner low-resistance separators to reduce internal resistance, and the use of more finely divided mixes and more active negative expander materials to increase and maintain active material surface area. Changes in operating procedure, based on studies of the effect of previous cycling history on subzero battery performance, established the 0 degree Fahrenheit cycle as most effective in increasing high-rate capacity at temperatures as low as −65 degrees Fahrenheit. Such a cycle improved high rate capacity at −65 degrees Fahrenheit about 50 per cent.

Fundamental studies using X ray, electron microscope, and other laboratory facilities revealed that the negative sponge lead electrode was more limiting than the positive electrode in low-temperature operation of the lead-acid battery. The occurrence of new compounds or reactions at subzero temperatures has not been detected at the negative electrode. However, the existence of fine lead and lead sulphate crystals and of a distorted highly active structure following 0 degrees Fahrenheit cycling of negative plates was evident, and, in terms of these, the heightened activity and improved performance of the negative plate at −65 degrees Fahrenheit was explained.

Lead-acid batteries of the 2H size, incorporating the improvements resulting from the development and research with this electrode system, have been constructed and exhibit good acid to active material balance, satisfactory life characteristics and improvements in cranking (high-rate), discharge time and 5-second voltage amounting to 127 per cent and $17^1/_2$ per cent respectively of specification requirements.

The work with nickel-cadmium alkaline storage batteries has been concentrated on the sintered plate type since this offered the greatest promise for military needs. In the course of the investigation of this electrode system a domestic process was developed for the preparation of nickel powder by the thermal decomposition of nickel carbonyl, optimum sintering techniques were developed, and impregnation procedures were simplified. As in the case of the lead-acid battery, the construction of sintered plate nickel-cadmium batteries with thinner plates, spaced closely together, has made possible the discharge of this type of battery at subzero temperatures at high rates with high material utilization. At normal temperature and a discharge rate of 0.6 ampere per square inch, the material utilization of the positive active material may be as high as 85 per cent.

Equipment for Instrument Calibration; *E. A. Gilbert* (*Radio Frequency Laboratories, Inc., Boonton, N. J.*).

Three types of calibration equipments have been developed which will find ready application as complete self-contained multiranged laboratory standards and power supplies. The standardized output currents and voltages obtained from these equipments can be applied to laboratory instruments and to the production calibration of small numbers of diverse measuring instruments. The three self-contained units, a d-c standard, an a-c standard, and a dual-potentiometer standard, supplant the assortment of various range instruments, standard resistors, decade boxes, and variable-frequency power supplies that have been previously required to calibrate even the most common types of electric instruments.

The unit for d-c instrument calibration is designed to calibrate the various types of current indicating instruments with full-scale current ranges between 0.75 microampere and 150 amperes. The full-scale direct voltage ranges covered are 0.075 to 1,500 volts. All ranges are calibrated within an accuracy of one-half of one per cent. The equipment standards are special Weston fan-type d-c instruments.

The unit for a-c instrument calibration is designed to calibrate a-c indicating instruments with full-scale ranges between 1.5 milliamperes and 200 amperes. The a-c outputs have full-scale values of 0.03 to 1,500 volts. The frequency of standardized output voltages and currents can be varied between 50 and 1,600 cycles per second. All ranges are calibrated to one-half of one per cent. The equipment's standards are special one-fourth of one per cent Weston electrodynometer-type instruments.

The dual-potentiometer equipment covers the same ranges as the d-c unit described, but with the much higher accuracy of one-tenth of one per cent or better. This unit uses two Leeds and Northrup type-*K* Brooks potentiometers with a precision Leeds and Northrup shunt box and a volt box.

The cabinets for the three units are of sheet steel finished in gray wrinkle enamel and are 61 inches long, 32 inches wide, and 59 inches high. Weight of each unit is approximately 900 pounds.

Power Measurement by the Hook-on Method; *A. J. Corson, A. L. Nylander* (*General Electric Company, West Lynn, Mass.*).

The "hook-on method" is here defined as the measurement of an electrical quantity, where the current component of such measurement is obtained by encirclement of the current-carrying conductor by a removable magnetic structure. This magnetic structure thereby is subjected to a magnetomotive force, which force is a unique function of the current and provides a magnetic flux for a secondary winding or an instrument mechanism. Available self-contained instruments are limited to current measurement. Some of these instruments have independent potential circuits for voltage measurement. Interest in extending this measurement method to active and reactive power has resulted in the development of the self-contained hook-on wattmeter. It was necessary that this instrument meet exacting requirements as to weight, simplicity of operation, and range of full-scale capacities (3 to 300 kw.).

Since power measurements involve circuits which will preserve phase angle relationships, it was evident that a direct application of ammeter magnetic circuits would not necessarily be satisfactory. The preferred construction consists of a ferrodynamic wattmeter, the field of which is energized by the current-carrying conductor through the hook. By making this field linear with respect to

current through the hook, and by using a spring-controlled moving system, the scale capacity is directly proportional to the potential circuit resistance. Range changing, therefore, can be accomplished by potential switching alone.

Multiple-range accuracy requires that the magnetic circuit deliver useful flux as a linear function of current and without a substantial shift in phase angle over a wide current range. This is accomplished as follows:

(*a*). The concept of a central main core of magnetic material, plus a leakage sleeve, was adopted. The cross section of the leakage sleeve is varied, as far as manufacture will permit, to be proportional to the leakage flux and, incidentally, contributes to the low weight ($3^1/_2$ pounds) of the instrument.

(*b*). Air gaps are interposed to provide a reluctance sufficiently high to dominate the magnetic circuit and to provide insulation between current and potential circuits.

(*c*). The magnetic hook must be in such mechanical form that it can be opened and closed. The effect of the resultant discontinuity in the magnetic circuit is minimized by the use of a long dove-tail joint.

(*d*). There is an appreciable lagging phase displacement of the mutual flux with respect to the current. Compensation is effected by lagging the potential circuit current correspondingly by a shunt capacitor.

The scale distribution for the six ranges is substantially linear. It is influenced by the linearity of the hook magnetization curve and by the moving coil reluctance torque. This reluctance torque is due to the circumstance that the total flux linking the moving coil, as a result of moving coil magnetomotive force only, is a function of coil position. The effect is usually negligible in a construction of this kind, but in the hook-on wattmeter, with its necessarily wide range of moving coil magnetomotive force, the error is appreciable. Compensation is, therefore, necessary and consists of a series magnetizing winding centrally located on the core. The winding provides a counter torque of approximately the same relationship as the reluctance torque.

This development has resulted in the extension of the hook-on method of measurement to include single and polyphase power. It has been accomplished by development of a lightweight portable single-phase hook-on wattmeter, having wide measurement range. The initial accuracy is three to five per cent of full scale, and quick indication is obtained by magnetic damping and a low moving-system free period. Connections are similar to those of the conventional single-phase wattmeter, allowing for the circumstance that the hook surrounds the current carrying conductor. Simple switching and direct reading scales have resulted in one-hand operation and minimum possibility of error in use.

The Use of Conductance Curves for Pentode Circuit Design; *A. H. Hodge, K. A. Pullen* (*Aberdeen Proving Ground, Aberdeen, Md.*).

This paper is an extension of an earlier paper on electron tube curve presentation and utilization which was presented at the 1949 Annual Institute of Radio Engineers Meeting. That paper showed the usefulness of contours of constant transconductance and plate conductance in design of triode circuits. A large group of equations useful with the method also was presented.

The application of these contours to multielectrode tubes is given further study in this paper. One method of curve presentation offers operating data on pentode tubes at any screen voltage desired within the tube ratings. The errors which are involved in use of the curves are less than the normal limits of tube tolerance.

This new curve presentation offers several advantages. The first is that design at otherwise awkward values of screen voltage becomes routine. The second is that factors showing greatest variation are emphasized. Correction for variations of plate voltage at fixed screen supply, being much smaller than that for screen variation, is provided by simple-scale correction curves which appear to give results within five per cent. The third advantage is that dynamic data are available directly, as with the earlier triode curves. Distortion determination is a matter of arithmetic rather than a graphical problem. In addition, a large group of design techniques is available in the literature (*Tele-Tech*, July and August, 1949) for solution of many special problems. A pair of nomographs which simplify calculations also have been published.

The present discussion is limited to a very brief résumé of the basic principles and development of the approach for best use in pentode amplifiers. The method can readily be extended both to variable screen voltage applications and to the more complex mixer tube operation.

Arc Drop of Hot Cathode Gas Tubes in Service—Measurement Methods and Data; *E. K. Smith* (*Electrons, Incorporated, Newark, N. J.*).

In maintaining production equipment to minimize down time, it is important to anticipate failure whenever possible. Complete test equipment for hot cathode gas tubes would not anticipate all tube failures, and in most cases the cost would be prohibitive. Changing tubes at definite time intervals is not a solution.

Fortunately, the most common manifestation of end of life is an increase in tube arc drop. This offers the hope that a single test, taken periodically, will permit removal of tubes before failure and without undue sacrifice of tube life.

The most indicative arc drop tests seem to be measurements taken under actual or simulated current operating conditions. Readings can often be taken, therefore, without interrupting service. Further, the measurements may be made with instruments which are usually available to maintenance men.

Due to the large ratio of peak to average current ratings of gas tubes, a wide range of current wave forms is possible. This makes the cathode-ray oscilloscope an outstanding instrument for arc drop measurements, since the drop occurring at the highest current may be observed. This instrument has already become standard equipment where maintenance of electronic controls is called for.

The complexity of tube operating duties and conditions has made it impossible for the tube manufacturer to establish, through life tests, end of life limits for arc drop which will cover all conditions. Either average or peak values are sometimes given for guidance. There is considerable probability, however, that the user may be able to determine satisfactory limits for tubes in his particular applications. Limits which have been established by experience on one type of tube should not be arbitrarily applied to other types or tubes of different manufacture.

A Cold Cathode Counting or Stepping Tube; *Mark A. Townsend* (*Bell Telephone Laboratories, Murray Hill, N. J.*).

Electronic digital counters may be considered as high-speed equivalents of mechanical counters, relay chains, or stepping switches. These high-speed stepping devices commonly employ chains of trigger elements such as hot-cathode multivibrators or cold-cathode glow discharge tubes. Each of the trigger stages requires one or two tubes and a number of resistors and capacitors.

This paper describes a new principle of tube construction which permits counting with a single tube having a minimum of three external connections and a single resistor. The tube has a single anode and a number of cathodes. The cathodes are constructed with a geometry which causes a concentration of the discharge in one portion and are arranged in a row with the concentrating portion of one adjacent to a low-efficiency portion of the next. The anode is connected through a load resistor to a positive power supply. The cathodes are connected alternately to ground (*A* cathodes) or to the pulse input lead (*B* cathodes). Between pulses a glow discharge is present on one of the *A* cathodes. Each negative input pulse causes a discharge to form on one of the *B* cathodes and extinguish on the *A* cathode. Because of the preference introduced by the concentration of the discharge, the glow is always transferred in a forward direction and moves from one *A* cathode to the next for each complete stepping pulse. Visual observation of the position of the discharge permits counting of input pulses with only three tube connections. Electric output signals can be obtained by making an external connection to each *A* cathode and using the discharge current to operate a relay or other indicating device.

The input signal need not have a critical amplitude or wave shape and may be applied at any frequency up to a limit of about 1,000 pulses per second set by the deionization requirements of the discharge. The driving power required is small enough to be supplied easily by electronic devices, and the output power is large enough to operate relays or other electromechanical devices. The absence of filament standby power makes intermittent operation economical and extends tube life. These operating characteristics in conjunction with a compact physical size and small number of circuit elements make it appear that the cold-cathode stepping tube will be a useful new tool.

Explosion Hazards in Industry and Their Relation to Electrical Installations; *Kennard Pinder* (*E. I. du Pont de Nemours and Company, Wilmington, Del.*).

Research and developments in the chemical industry during the last 30 years in building a new world by the synthetic creation of substitutes for cloth, wood, leather, metals, and a wide assortment of other commonly used materials, has filled our industrial plants with sources, not only of air contaminants, but with serious hazards to life and property. Flammable liquids and gases create fume- and vapor-air mixtures that are highly explosive. In addition, many dust-laden atmospheres are potential

explosion hazards. The subject is a considerably larger one than a cursory examination would suggest. Today approximately 200 different types of industrial plants have explosion-hazardous conditions in one department or another.

In order for an explosion hazard to be present, there must exist a mixture of combustibles with air or oxygen within the explosive limits, a spark or a rise in temperature to the ignition point. Our problem as electrical engineers is to use precautionary measures that will prevent explosions and fires from electrical causes, such as arcing, sparking, overheating, and static discharges.

The imposing array of materials which in gaseous or vapor or dust conditions can be rendered highly explosive means that the electrical engineer who designs the safety measures has to be well acquainted with chemical principles in order that the installation of electric equipment can be carried out at least expense and yet be efficient.

The ability of a flammable liquid to form explosive mixtures is determined largely by its vapor pressure, volatility, or rate of evaporation. The important items to be determined in hazardous gas- and vapor-air mixture locations are

1. At what temperature will ignition take place?
2. At what mixture ratio do the gases reach an explosive sta e?
3. How rapid is the pressure rise in concentration?
4. What is the optimum concentration in a closed space? (Assumed to be the point at which all the gas in suspension will use all the available oxygen in the mixture. At this point the maximum pressure and rate of rise will occur.)

Intensity of a dust explosion depends upon:

1. The chemical and thermal properties of the dust.
2. The size and shape of the particles.
3. The concentration and degree of dispersion of the dust in the air.
4. The proportion of inert dust in the air.
5. The moisture content.
6. The size and temperature of the ignition source.

Many flammable gases are more or less toxic and thus involve a health as well as a fire and explosion hazard. To control concentrations of toxic or injurious vapors in areas to levels below their maximum allowable concentrations for health makes it necessary to provide much more effective ventilation than that required for the reduction of the mixture below the lower explosive limit.

The fundamental requirement for electric equipment operation in a hazardous gas- or vapor-air mixture is to prevent the flames which may be ignited in equipment and wiring raceway enclosures from passing outside to the surrounding hazardous atmosphere. The fundamental requirement for electric equipment operation in a hazardous dust atmosphere is dusttight enclosing cases for both equipment and wiring raceways that are designed to limit the possible accumulation of dust and prevent the ignition of the dust on or adjacent to equipment.

Underwriters' Laboratories' Classification and Test of Electric Equipment for Hazardous Locations; *A. F. Matson (Underwriters' Laboratories, Inc., Chicago, Ill.).*

Standards and methods of tests of electric equipment for safe use in hazardous locations have been developed by Underwriters' Laboratories, Inc., in close co-operation with the electrical industry. The development of these Standards makes it necessary to classify and clearly define hazardous locations in order that inspection authorities may judge as to the need for explosionproof or dusttight equipment in any given area. This function is fulfilled by the "National Electrical Code, Article 500." The National Electrical Code also serves as a basis of the requirements for electric equipment for hazardous locations tested and listed by Underwriters' Laboratories, Inc.

The explosion hazards are not the same for all flammable gases or vapors, or for all types of combustible dusts. In view of this, electric apparatus is tested and listed by Underwriters' Laboratories, Inc., for use in one or more of the following groups: Class I, Groups *A*, *B*, *C*, and *D;* and Class II, Groups *E*, *F*, and *G*, as given in the National Electrical Code.

Class I (explosionproof) electric apparatus is required to be so constructed that gas or vapor-air explosions occurring within the apparatus will not ignite surrounding gas or vapor-air mixtures. In other words, the enclosures of the devices are required to withstand, with a factor of safety, specified gas or vapor-air explosions without bursting or loosening of joints, and the joints between sections or parts of the enclosure are required to be of metal-to-metal type with adequate widths and close clearance to arrest the propagation of flame from the interior of the enclosure to the surrounding atmosphere. Explosionproof devices must also operate with external temperatures safely below the ignition temperature of the flammable gas or vapor in which they are intended to be used.

Class II (dusttight) electric apparatus is not designed to resist internal explosions of dust-air mixtures but are required to be dusttight and to operate at temperatures safely below the ignition temperature of the dust.

To determine safety of operation, electric equipment for Class I hazardous locations is tested in the presence of specified explosive gas or vapor-air mixtures, and Class II equipment is tested in the presence of specified combustible dust-air mixtures according to methods outlined in the Standards of Underwriters' Laboratories, Inc.

Radiophoto Practices and Problems; *R. E. Hammond (RCA Communications, Inc., New York, N. Y.).*

Interconnection of international radiophoto circuits with the wirephoto and telephoto systems operated by the press associations within the United States has long been delayed because the various equipments operate on different standards, but recently machines modified to match those operated on the international circuits have been installed in the New York offices of the press associations which makes it possible to pick up and deliver radiophotos over a tie-line instead of by messenger.

Continuing efforts toward the standardization of radiophoto and telephoto equipment throughout the world are resulting in progress which ultimately will bring more efficient and more economical operation. At the 1948 CCIR meeting in Stockholm it was agreed that the recommended limits for subcarrier frequency-modulated radiophoto signals would be 1,500 cycles for white and 2,300 cycles for black, that the recommended speeds of cylinder rotation would be 60 and 90 rpm, and that the indexes of co-operation would be 264 and 352. The question of standardization on a cylinder having a diameter of 70 millimeters and length 300 millimeters was discussed and recommended for further study. A United States preparatory committee established by the United States Department of State has been carrying on these further studies and has just prepared a recommendation for submission at the next meeting of CCIR tentatively set for Prague in 1951. This recommendation proposes adoption of a cylinder having 70-millimeter diameter and 300-millimeter length, and the use of 45 rpm in addition to the already adopted 60- and 90-rpm cylinder rotational speeds.

In addition to the improved efficiency which will result when these standards are put into practice, it seems desirable to explore the development of a system for the transmission of radiophotos by direct shift of the radio-frequency carrier. Such a system would obviate the necessity for a modulated transmitter as used with subcarrier frequency modulation and permit the interleaving of message and radiophoto traffic on the same facilities without an appreciable loss in setting up time. It also seems reasonable to expect an improvement in the signal-to-noise ratio and a saving in bandwidth as compared to operation with subcarrier frequency modulation. However, in considering such a system for handling halftone material, the stability of the receiver is likely to present a problem. Another question which merits investigation is the amount of deviation required for optimum results, recognizing that conservation of bandwidth and the amount of terminal equipment already designed for a deviation of 800 cycles are important factors in the choice of deviation for frequency shift radiophoto.

Facsimile Broadcasting; *John V. L. Hogan (Hogan Laboratories, Inc., New York, N. Y.).*

This paper traces the development of facsimile broadcasting by radio from the "rayfoto" of Austin G. Cooley through the various subsequent developments up to the time of the promulgation by the Federal Communications Commission, in 1948, of Standards of Good Engineering Practice for Facsimile Broadcasting.

Facsimile is the fourth of the radiobroadcasting services to reach the public. Standard or amplitude-modulation sound broadcasting of speech and music came first. It was followed by frequency-modulation sound broadcasting. The third service to find public acceptance was television, which combines sound radio and radio motion pictures.

As the fourth service, facsimile is just beginning to go into general use. More or less like television, the broadcasting of facsimile programs will first be directed to receiving sets and display recorders located in public places such as hotel lobbies, airport terminals, and theater lobbies. As regular programs become available on a broadcast basis it is expected that home receiving sets with facsimile recorders, or facsimile recorders for attachment to standard frequency-

modulation sound receivers, will get into production. The inevitable consequence of quantity manufacture is to bring down cost, and thus facsimile receivers are expected to become available at such reasonable prices that they can be purchased and used by the average home owner. In this way, the publication and radio delivery of a facsimile newspaper to the public should become an accomplished fact.

By the use of multiplex it is possible for any frequency-modulation station to operate two simultaneous services without mutual interference. Thus, in addition to the normal frequency-modulation sound channel carrying speech and music, the frequency-modulation broadcaster has available, on the same carrier wave, an entirely different service which delivers printed matter from the broadcast receiving set. The cost of adding a multiplexed facsimile channel to a frequency-modulation sound station is relatively small, as may be the cost of facsimile operation and programming. Since the Federal Communications Commission now permits the sale to advertisers of white space on the pages of the facsimile newspaper, the frequency-modulation broadcaster is provided with a new source of income which should more than meet the expense of the facsimile operation and thus contribute to the cost of the frequency-modulation sound operation.

An 1,800-Cycle Synchronous Motor; *A. G. Cooley* (*Times Facsimile Corporation, New York, N. Y.*).

In portable facsimile equipment there is a requirement for a compact, reliable synchronizing system that requires very little electric power, since in many cases the power must come from storage batteries, and usually the synchronous motor must be driven by a vacuum tube amplifier. The system developed by Times Facsimile Corporation involves a tuning fork oscillator having an output frequency of 1,800 cycles. The signal is amplified to drive an 1,800-cycle synchronous motor. This eliminates the necessity for frequency dividers and the use of heavy, inefficient 60-cycle motors that usually require mechanical decoupling and damping devices to obtain a smooth drive.

The 1,800-cycle synchronous motor is of the Lacour phonic wheel type and is brought up to speed by a start motor in the same frame. High efficiency in the phonic wheel motor is accomplished by the use of a small air gap between the rotor and poles of 0.001 inch. The rotor is advanced one pole for each cycle of power because the field winding is in the plate circuit of the tube and does not reverse polarity.

Successful operation of the motor hinges to a large extent on the flywheel action of the start rotor and its decoupling from the shaft. The motor used in the facsimile equipment will deliver 1/75 of a horsepower at 1,800 rpm when operating in a tube circuit having 400 volts on the plate and a plate current of 80 milliamperes.

Television Transient Analyzer; *Joseph Fisher* (*Philco Corporation, Philadelphia, Pa.*).

The television transient analyzer was designed to facilitate the measurement of the over-all transient response of television receivers. The analyzer also may be used as a double-side-band radio-frequency picture generator, making possible an accurate comparison between picture detail and transient response.

The ability of a television receiver to reproduce a good picture is best analyzed by the measurement of its transient response. Phase and amplitude distortion in the low-frequency spectrum may be tested by square waves having frequencies between 60 cycles and 50 kc. The rendition of fine detail without excessive ringing or smear may be judged by the response of the receiver to the application of a standard radio-frequency carrier modulated with a 100-kc square wave. To achieve accuracy in measurement, the distortion inherent in this equipment has been held to a minimum.

The transient analyzer consists of four units: regulated power supply, square-wave clipper, wide-band modulator, and marker generator. These units are individually shielded and mounted in a single metal box. The analyzer has been designed to operate in conjunction with three pieces of commercial test equipment, namely: radio-frequency signal generator, square-wave generator, oscilloscope.

The source of modulating voltage is a commercial square-wave generator. The rise time of many commercial units is greater than 0.2 unit second so a 3-stage clipper unit is incorporated in the analyzer to reduce this rise time to less than 0.05 unit second.

Separate modulator units for various television channels are employed and the design is such that these units may be changed very quickly. A balanced modulator employing two *6BH6* tubes is used. Unmodulated carrier from a standard signal generator is applied push-pull to the grids while the 100-kc square wave is coupled to the common cathode circuit. The bandwidth of the output circuit is ±15 megacycles and a 300-ohm balanced output is provided for connection to the antenna terminals of a television receiver. With an input of one-tenth of a volt of carrier signal, the open circuit voltage across the output terminals of the analyzer is about 30,000 unit volts.

For making over-all transient measurements on a television receiver the output of the analyzer is connected to the input terminals of a television receiver. A wide-band oscilloscope having a rise time of 0.05 unit second and a frequency response within three decibels from five cycles to eight megacycles is connected to the lead going to the cathode-ray picture tube. To eliminate measurement error a probe having the same capacity as the picture tube grid is connected to the grid lead in place of the cathode-ray tube. The oscilloscope is triggered by the 100-kc square wave and a sweep having a duration of about two unit seconds is used.

A marker generator which consists of a quenched oscillator operating at 20 megacycles is connected to the cathode of the oscilloscope tube to place time marker dots on the transient presentation. These time dots are placed 0.05 unit second apart and correspond to about one-hundredth of an inch of horizontal displacement on a 10-inch television tube.

For over-all transient tests, the depth of modulation should be moderate (30 per cent) so that any peculiarities of vestigial side-band transmission near 100 per cent are avoided.

The transient response may either be photographed from the oscilloscope tube or recorded on graph paper. A composite video signal of known quality may be used to modulate the analyzer in place of the 100-kc square wave and this information may be photographed directly from the television receiver cathode-ray tube. The comparison of the two photographs provides an accurate means of establishing standards for the transient response as related to picture definition.

Progress and Development of Crystal Unit Test Oscillators; *L. F. Koerner* (*Bell Telephone Laboratories, Inc., New York, N. Y.*).

Early crystal unit test oscillators as conceived some 20 years ago were principally duplicates of the actual equipment in which the crystal units were to be utilized, a practice which resulted in a large variety of test circuits and procedures for testing. It is now recognized that a knowledge of the equivalent electrical elements making up the crystal unit is essential to the circuit engineer, and that the older conception of frequency and activity, the latter being an attempt to express the quality of a crystal unit in terms of a particular oscillator circuit, do not define adequately its characteristics.

The equivalent electric circuit of the crystal unit contains essentially a resistance, an inductance, and two capacitances, which together with frequency define the performance of the unit. Crystal units are available in the frequency range from about 1,000 cycles to 100 megacycles. Their resistance range may vary from less than 10 ohms to over 150,000 ohms, the inductance from a few millihenries to nearly 100,000 henries, and the capacitances from about 0.001 micromicrofarad to 50 micromicrofarads. Modern test oscillators, with frequency and capacitance measuring apparatus as auxiliary equipment, will measure these quantities with accuracies sufficient to meet present requirements.

The transmission measuring circuit is proposed as the standard reference circuit for comparison with the test oscillators. It lends itself admirably for this purpose due to its simplicity and the ease with which its accuracy may be predetermined and maintained. This circuit consists of an oscillator, a crystal network, and a detector. The frequency of the oscillator is adjusted for maximum transmission through the crystal network and a measurement of the frequency of the oscillator under this condition, together with simple capacitance measurements made with a capacitance bridge, will furnish sufficient information whereby the values of the parameters of the crystal unit may be determined and compared with similar measurements made in the test oscillators.

A Television Impulse Interference Generator; *John D. Fogarty* (*Philco Corporation, Philadelphia, Pa.*).

A television impulse interference generator can aid in the design of television receivers by providing a quantitative means of comparing the performance of receivers in the presence of impulse noise. The design of inexpensive synchronizing circuits with low susceptibility to impulse interference is one of the chief aims of television manufacturers.

The testing methods used in circuit research have hitherto been only approximate and not capable of quantitative or repeatable results. It is desirable to have a generator which will provide the experimental receiver with a test signal and impulses whose amplitudes are known and independently controllable over a wide range of conditions. The relative radio-frequency phase of the impulses with respect to the signal carrier should be adjustable. The generator should be capable of producing the impulses singly or in a group so that cumulative effects can be observed. Finally, the position of the impulse group upon the received picture should be variable.

Measurements of impulse noise of the type produced by electric-appliance motors and automobile ignition systems have shown it to have a continuous frequency spectrum up to at least 600 megacycles. The frequency spectrum produced by a narrow pulse of radio-frequency energy can reasonably approximate that of a noise impulse over the limited bandwidth accepted by a television receiver. In the test arrangement, a low-power television transmitter delivers the test signal to the receiver through a calibrated attenuator. A portion of the carrier energy from a low-level stage of the transmitter is gated by a short pulse to produce a burst of radio-frequency energy of shorter duration than the receiver can resolve. This radio-frequency burst is passed through a separate attenuator and mixed with the signal entering the receiver to provide the "impulse noise." The use of carrier-frequency energy for the impulse allows the relative phase of the impulse and signal to be varied by changing the length of the path between the gating stage and the mixing point. Since impulse noise has a continuous frequency spectrum, its effects are practically the same on all television channels, and measurements for one channel should be representative of the others. The use of only one channel simplifies the radio-frequency phase calibration.

The positioning of the impulses on the picture as vertical groups is accomplished by timing the triggering pulse from the synchronizing pulses of the video signal used to modulate the transmitter. The pulser stage of the pulse-positioning unit is driven by line-synchronizing pulses separated from the composite video signal and delayed by a variable amount to control the horizontal placement of the impulses on the picture. Vertical grouping of the impulses is provided by gating the line pulses with a pedestal of variable duration. The vertical placement of the group is governed by a delayed field-synchronizing pulse which is used to initiate the gating pedestal. Provision is made for removing every other field pulse so that the impulse group recurs once each frame, thereby leaving the second field untouched to serve as a reference for observing any displacement of the first by the interference.

Preliminary tests with this impulse interference generator on receivers using blocking-oscillator and automatic-frequency-control-type synchronizing circuits demonstrated the recovery characteristics of these circuits in a striking manner. The overloading effects of large noise impulses were clearly evident. The equipment promises to be a useful research tool for studying impulse-noise effects, particularly under conditions of low signal strength.

A New Cathode-Ray Oscillograph for Impulse Testing; *W. G. Fockler (Allen B. DuMont Laboratories, Inc., Passaic, N. J.).*

Impulse testing laboratories throughout the United States have been using the cold-cathode oscillograph for many years. It has been the thinking of many of these people that this equipment, though satisfactory, is outdated.

Some time ago, the type *5RP* cathode-ray tube, a sealed-off high-voltage type, was developed. This tube had the high brightness and good definition required for recording impulse wave shapes. This work was followed by development of a practical commercial instrument furnishing accelerating voltages for the tube to use its maximum capabilities. While this combination of equipment was valuable in many laboratory applications, it was not equipped with the special circuits and components necessary for impulse testing. Accordingly, a new instrument has been developed during the past year incorporating these features. The cathode-ray tube used is the *5RP11A* with a thin aluminum backing on the screen material to improve brightness and stability.

The unit contains a precision voltage calibrator accurate to plus or minus one per cent, regulated accelerating voltage power supplies, a wide range of crystal-controlled frequencies for timing waves, adjustable trigger or sweep delay, and an adjustable line phase delay circuit for use where the test piece is energized simultaneously with 60-cycle power and the impulse applied at either the positive or negative crest.

Signal delay lines required considerable study. The lumped constant type of line was investigated thoroughly because of its minimum space requirements and convenience; however, it could not be made to reproduce the pulse accurately. Since the signal input impedance of the equipment is 75 ohms, *RG59/U* coaxial cable was found to be the most satisfactory to get the desired signal delay. By the use of a small matching section, the cable will reproduce the pulse very accurately and does not introduce reflections such as obtained with the lumped constant line.

A new camera, developed specifically for the oscillograph, has an f1.5 lens, uses 35-millimeter film, and has provision for exposing and removing single frames. The shutter has only *T* and *B* openings to make it as foolproof as possible.

Cable Insulations for Chemical Plants: Field Experience and Tests—Insulations and Jackets; *C. S. Latham, A. A. Jones, L. L. Carter (Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y.)*

In the early days of the electrification of industry, the choice of insulations and jackets or sheaths for electric conductors was relatively limited. The insulations were various natural rubber compounds, varnished-cambric, or oil-impregnated paper. The coverings were lead sheaths or, for less severe locations, various braids.

Operating conditions in the chemical industry were oftentimes sufficiently severe that the maintenance of insulated cable in underground ducts or conduit became impractical because of destruction of insulations and sheaths. It was quite common to find the electric circuits handled on either bare or insulated conductors installed on insulators to avoid contact with destructive chemicals such as encountered in the underground systems. This was especially true of the electrolytic refining operations.

In recent years, several new and very useful insulating and jacketing materials have been developed. The thermoplastic materials most commonly used are polyvinylchloride, polyethylene, Rulan (a thermoplastic compound derived from polyethylene), and related synthetic resins. The thermosetting compounds are Neoprene, Buna S, and Butyl synthetic rubber with related rubberlike materials. As each of these materials became available, extensive laboratory and field tests were started, some of these going back almost 20 years.

The most important general conclusion as a result of this work is that each installation must be carefully considered as to the operating conditions and a choice of insulation and jacket based upon the specific situation. General conclusions resulting in the blanket use of any one of these newer insulations or jackets for all types of installations is a mistaken approach and will result in an unsatisfactory combination unsuited for the service. The next important general conclusion is that the most careful installation methods and the best design of duct or conduit systems is necessary regardless of the merits of insulations and jackets.

Further general conclusions as to the application of these materials are as follows. The polyvinylchloride-insulated wires and cables are being used increasingly for the low-voltage electric circuits in chemical plants; the synthetic rubber insulations with Neoprene jackets have been quite satisfactory in place of the earlier rubber and braid or rubber and lead sheath cables for the low- and intermediate-voltage ranges.

Increasing amounts of butyl rubber with neoprene jackets are being used for operation up to 15,000 volts; polyethylene, the newest of the materials, has been installed in a substantial number of circuits at the intermediate voltages with a few experimental installations up to 15,000 volts or higher.

Varnished-cambric or oil-impregnated paper-insulated cables with lead sheaths and Neoprene jackets of the glass or cotton reinforced-hose types or thermoplastic jackets, still represent the most conservative and reliable installation above 10,000 volts and, in some cases, above 5,000 volts. None of these newer materials may be used as jackets for insulations such as varnished-cambric or paper as a substitute for lead sheath where the cable lies in contact with moist ducts or in condensate-filled conduits. Such cables have been satisfactorily installed in aerial service on messengers.

A knowledge of the chemicals which may be encountered in the duct or conduit system, ambient temperatures, circuit characteristics, and so forth, are absolutely necessary in choosing cable which may be depended upon for satisfactory operation.

A selection of metallic conductors having ample cross section to handle the load, and avoiding extremely high operating temperatures, will often provide electric circuits of much greater reliability than will be obtained with extreme care in choosing an insulation or jacket of supposedly remarkable characteristics with the use of a conductor size which results in maximum operating temperatures.

Cable Insulation for Chemical Plants; *R. C. Graham (Rome Cable Corporation, Rome, N. Y.).*

Recommendations for chemical plant wiring may be summarized as follows.

Thermosetting Materials. A recently developed Buna S compound combining moisture as well as heat-resistant characteristics is recommended for most 600-volt a-c general-purpose applications. An oil-base ozone-resistant insulation is suggested for voltages 600–15,000 alternating current or for d-c circuits. Either of these insulations may be protected by a polychloroprene sheath unless severe oil or gas conditions are present, in which case either a Buna N or lead sheath is proposed.

Thermoplastic Materials. The so-called vinyl (polyvinyl chloride) type of insulation and sheath is today the most popular material for chemical plant wiring due to its simplicity, low cost, and excellent resistance to most chemicals and flame. As with rubber, a combined heat and moisture resistant compound is available today which is recommended without further protection for most 600-volt a-c circuits. A new vinyl insulating compound using resinous-type plasticizers has been developed which will permit substantially greater resistance to temperature, cold flow oil, and gasoline.

Polyethylene is rapidly becoming a close second to vinyl in popularity because of equally attractive cost and properties. Polyethylene may be recommended for higher voltages than vinyl and for d-c circuits in wet locations. Although conventional polyethylene burns readily, a newly developed flameproof polyethylene is now available which also provides the other desired characteristics of polyethylene.

Polytetrafluorethylene and silicone rubbers present interesting future possibilities for chemical plant wiring.

A Critical Examination of Heat Sources and Sinks for Heat Pumps; *Charles H. Coogan, Jr. (The University of Connecticut, Storrs, Conn.).*

There are many possible sources and sinks for the residential heat pump such as the atmosphere, shallow horizontal ground coils, and vertical wells. Direct evaporation, in the case of sources, or direct condensation in the case of sinks may be used. Auxiliary transfer fluids, for example, water and alcohol mixtures, may be used also.

A comparison of the effect on the probable coefficient of performance and the probable size of compressor necessary for the same residence located in ten different localities in the United States was made. The cities examined were Minneapolis, Omaha, Hartford, Buffalo, Little Rock, Raleigh, Austin, Seattle, Miami, and Los Angeles.

The basic house was located in Hartford, with a design heat loss there of 50,000 Btu per hour. Certain criticisms can be made of this method of analysis; namely, it is likely that construction and the ratio of window to wall area will differ between north and south, and so forth; however, in a simple analysis these factors are justifiably neglected.

Examination of the results indicates that if two criteria are combined to determine the desirable heat source and sink, namely, a certain minimum coefficient of performance and a certain maximum installed horsepower; then the several localities fall into about three groups. In one group the atmosphere will be satisfactory for both source and sink, in another group the ground coil probably would be advisable for heating and the atmosphere may be used as a sink for cooling, and finally a third group where it would be absolutely essential to use a ground coil for heating but where due to extreme coil size it might be advisable to use a combination of ground coil and atmosphere in order to reduce the size of ground coil. It probably would be necessary to use the atmosphere as a sink in these localities. The analysis also makes clear the regions in which winter heating or summer cooling will control the design where different combinations of sources or sinks are used. Well water will give the best coefficient of performance and the smallest installed capacity unit provided that it is available. However, since it is likely that the water will have to be returned to the earth and with the many other considerations including expense of well drilling, this method appears less attractive as a source or sink. Direct expansion in wells without water circulation is not likely to be successful due to the cost of drilling vertical holes in comparison with cost of horizontal trenches.

Some Practical Aspects of the Use of Earth as a Heat Source; *G. H. Hickox (Engineering Experiment Station, University of Tennessee, Knoxville, Tenn.).*

A study of extraction of heat from the soil is being carried on by the Engineering Experiment Station of the University of Tennessee in co-operation with Tennessee Valley Authority to determine the feasibility of using the earth as a source of heat for the heat pump.

Field measurements are being made to determine the thermal properties of soils at seven widely separated sites in the Tennessee Valley area. Studies have been made of the theoretical equations for transient rates of heat flow from line and cylindrical sources under conditions of both continuous and intermittent operation. The theoretical equations have been checked experimentally, both in a box containing soil and with an electrical analog.

The results of both the theoretical and the experimental studies indicate that for soils having thermal properties measured in the Tennessee Valley area, ground coil temperatures below freezing are required. It is also shown that intermittent operation reduces the temperature drop only about 18 per cent. The results of the experiments to date are limited by the assumption of an infinite soil mass and a uniform temperature.

The results will be modified by the presence of the ground surface and the variable temperature at that surface, by the spacing of parallel pipes required on small lots, and by the freezing of the soil around the pipes during the heating season. Further work is underway to determine the effect of these factors.

Some Heat Pump Design Problems; *T. C. Johnson (General Electric Company, Bloomfield, N. J.).*

The inherent characteristic of a refrigerant motor-compressor operating in an air-to-air domestic heat pump to be able to supply heat almost contrarywise to the need of the house for it results from the fundamental thermodynamic properties of the refrigerant and the use of a constant-speed a-c motor. Extreme short cycling and overloading of the motor may occur unless special controls are added. Summer requirements for fewer Btu's but higher relative motor loadings complicate the problem.

Application data and methods of selecting heat pumps need co-operative development by all parties. Initial costs are sharply increased by lower design temperatures obtained by too conservative methods. A careful study of operating data is needed to relate weather data, building design, and required heat pump performance characteristics. Transient effects, including the probability of the degree and duration of severely cold weather, are quite important.

Motor and control application problems include: frequent starting of 3- and 5-horsepower motors in residential units with possible voltage dip; capacity modulation of compressors probably needed, possibly involving multiple motor-compressors; possible use of special motors and compressors with high efficiency to give greatest year around economy.

The ultimate "package unit" must have reliability approximating other proved household appliances and utilities.

Conductive Rubber Radiant Electric Heating; *R. C. Cassidy (United States Rubber Company, New York, N. Y.).*

This paper describes the adaptation of conductive rubber to electric radiant panel space heating. Studies indicated certain inherent advantages existed in electric space heating by means of a ceiling radiant panel. The primary advantage existed in the economics of the use of electric energy as a fuel. The broad consumer advantages to radiant heating combined with the advantages of electric heating has developed extensive interest and activity in this field.

Conductive rubber is a natural rubber to which has been added submicroscopic carbon black permitting the conduction of electricity. It provides the ideal element for low-temperature radiant heating since it permits a completely uniform heating surface over a large area. The particular conductive rubber radiant panel concerned herewith is a laminated construction containing phenolic-impregnated paper, asbestos board, and the conductive rubber heating element. Standard dimensions and wattages have been established. They are limited to a ceiling location as a result of performance evaluation of radiant panels in floor, wall, and ceiling locations. Installation and wiring are conventional.

Technical advantages of electric ceiling radiant heat to the consumer are concerned primarily with the possibility of reduced heat transmission losses through surfaces. Reduction of air movements present the possibility of reduced heat transfer coefficients. Reduction in temperature gradient on days of extreme temperatures further permits an anticipated reduction in transmission losses. Electric energy is the basic standard for measuring heat losses and will evaluate the degree of this reduction.

Technical advantages of electrical ceiling radiant heat to the producer of electric energy are concerned with reducing the connected

heating load and raising the demand load factor. Proper engineering combined with inherent "pickup" characteristics permit reduced connected loads with conductive rubber radiant ceiling panels. High load factors are essential for comfort with heat in radiant form. Long periods of nonoperation of the radiant panels cause discomfort in the heated space. Poor load factor indicates poor design analysis.

A substantial new market for electric energy exists for a properly designed and installed electric radiant panel heating system.

Radiant Electric Heating; *L. N. Roberson (L. N. Roberson Company, Seattle, Wash.).*

Radiant electric heating has several advantages, including no air ducts or radiators, no visible parts other than the thermostat and switch, minimum temperature differential between floor and ceiling of two degrees Fahrenheit or less, minimum dust disturbance, and reduction of redecorating costs.

Heatsum cable, a one-eighth-inch diameter wire with a special high-temperature water repellant insulation may be imbedded in the standard plaster finish, in concrete floors, or pulled into special raceways consisting of corrugated metal sheets to supply the heat source for proper panel temperature.

One and a half cents per kilowatt or less is considered a practical rate for heating when the buildings are properly insulated.

Electric radiant heating is adaptable to off-peak use, due to the storage capacity of plaster ceilings and concrete floors. Ceilings hold the room temperature for $1^1/_2$ hours with only a 2-degree temperature drop. Concrete floors drop about a degree an hour after power is shut off. The average person does not notice a 3-degree to 4-degree temperature change.

Several power companies have a rate schedule permitting $7^1/_2$ to 10 kw of demand without a demand charge. A demand charge is levied for each kilowatt of demand over the predetermined limit. A schedule of this type encourages the customer to install load limiting equipment that drops or limits the heating load while the appliance load is excessive.

Room thermostats on inside walls give excellent control located anywhere from one foot from the floor to a foot from the ceiling.

Electric ranges, toasters, mangles, lights, and refrigerators, add to the total heat available. Most of the heat load on Heatsum cable radiant installations occurs between midnight and 9:00 a.m., making a desirable load for the utilities.

Conduction Phenomena in Gases; *J. P. Molnar (Bell Telephone Laboratories, Murray Hill, N. J.).*

Under ordinary circumstances a body of gas behaves like a very good insulator. When an electric field of sufficient strength is applied to a pair of electrodes in the gas, its insulating properties may be suddenly lost, and it will behave like a good conductor. This transition, commonly called breakdown, is caused by the sudden multiplication of the electrons and ions always present (on account of the action of cosmic rays) to a very much larger number.

The detailed mechanisms by which the multiplication is brought about are distinctly different for the cases of high-frequency fields, d-c fields at low gas pressure and d-c fields at high gas pressure.

The high-frequency mechanism is the simplest. Electrons, which normally have a highly random motion, are accelerated by the action of the field so as to have a random motion with a much wider spread of velocities. The fastest electrons can then ionize neutral atoms, and when these ionizations produce new electrons faster than electrons are lost to the walls by diffusion, breakdown occurs.

In d-c fields at low pressure the spread of random electron velocities is similarly increased by the action of the field. At the same time the electrons acquire a net drift velocity in the direction of the field, so that they are lost to the anode much more rapidly than if they moved simply by diffusion. It happens, however, that the positive ions impinging on the cathode will produce new electrons. Thus the electron density will increase indefinitely if an electron in crossing the gap can produce enough ions by ionization to cause the emission on the average of more than one electron at the cathode.

At high gas pressures and d-c fields the breakdown mechanism is more complicated and understood at best only qualitatively. Space charge distortion of the field combined with photoionization effects are used to explain the observed phenomena. A striking characteristic of this type of breakdown is its speed. Times as low as 5×10^{-10} second have been measured between the instant of voltage application and breakdown.

Cable Insulation for Chemical Plants; *F. S. Glaza (The Dow Chemical Company, Freeport, Tex.).*

Selecting insulation for wire and cable to be used in a chemical plant is a combination chemical and electrical problem. Electrolytic plants, which break down brines and salts into their elements, offer the greatest problem, since, in addition to the highly active chemicals present in the atmosphere of such plants, there is the additional hazard of electrolysis to contend with. Synthetic plastics, the products of these same chemical plants, have been the answer in most cases.

For motor power wiring and control, rubber-insulated and Neoprene-jacketed over-all or polyvinyl-insulated and polyvinyl-jacketed, type-*TW* insulation without any protective conduits or ducts have given a very good account of themselves. Likewise, polyvinyl-insulated and polyvinyl-jacketed switchgear control cable without any metallic or leaded sheath has eliminated any damage from electrolysis or chemicals in the ground or in the air. In power plants serving chemical plants, varnished cambric for 2.3-kv service also has had an excellent record. However, the importance of terminating such cables will give synthetic plastic-insulated cables a preference in future installations. Cables serving as feeders at 13.8 kv and as apparatus interconnections have a good record but have furnished some difficulty because of the lack of a good plastic moisture seal. Metallic moisture seals are not favored because most of the cable is installed aerially and is subject to failure due to vibration, temperature changes, load changes, and so on. Development of synthetic plastic insulation, with proper terminating devices for apparatus, would also be preferred in the future, when manufacturers of this type of cable are willing to furnish some assurance of its reliability.

Power System Fault Control; *AIEE Committee on Protective Devices.*

The increased short-circuit concentrations that are being caused by the large and rapid postwar expansion of our power systems have made it necessary for those systems to face some serious problems in planning for the control of the faults. Certain broad and basic principles of fault limitations and removal should be chosen by each power system and be included in its philosophy of future system development.

The means of short-circuit control by expanding power systems may be classified into ten basic methods. These are: replacement of circuit breakers, current-limiting devices in phase wires, current-limiting devices in neutrals, resonant grounding, isolated phase construction, sectionalization within stations, sectionalization of systems, unit arrangements, pretripping, and delayed tripping.

Power systems may be classified into five categories in accordance with their methods of fault control. These are: large metropolitan systems which have large ground fault currents, large metropolitan systems which have small ground fault currents, metropolitan systems of medium size, high-voltage transmission systems, and metropolitan-transmission systems.

There is, of course, a considerable contrast in the principles of fault control for the metropolitan and transmission systems. The former uses a large number of relative-short tie lines and many circuit breakers as compared with its miles of line. As the system grows, the replacement of all its circuit breakers with larger circuit breakers becomes too costly, and in some cases, impossible. A compromise is the usual solution. This type of system is so "closely-knit" inherently, that fault-limiting devices and methods can be used rather freely without undue sacrifice of operating flexibility. Some circuit breakers have to be replaced, but for the most part the short-circuit currents are lowered by such expedients as a reduction in tie line connections, splitting of busses, sectionalization both within stations and between areas, phase isolation, current-limiting reactors, double winding generators, split-winding transformers, neutral impedances, synchronizing at the load, and pretripping.

On the other hand, the high-voltage transmission system uses long lines and has only a few circuit breakers as compared with its miles of line. The ratio of investment in circuit breakers to investment in lines is very much smaller than in a metropolitan system. It generally can afford to replace inadequate circuit breakers with circuit breakers of adequate interrupting capacity. It is inherently a high-impedance ("loosely-knit") type of system, and it is rarely necessary or advisable for a high-voltage transmission system to sacrifice its operating flexibility for the sake of reducing its fault duty.

It is almost unnecessary to remark that fault control, as applied to metropolitan-transmission systems, partakes of the methods used on each of these systems.

1950 Great Lakes District Meeting to Be Held in Jackson, Mich., May 11-12

Under the leadership of C. D. Malloch as Chairman and A. W. Rauth as Vice-Chairman, plans are being perfected for the AIEE Great Lakes District Meeting to be held at the Hotel Hayes, Jackson, Mich., on Thursday and Friday, May 11 and 12, 1950.

The technical program will be woven around the theme "the economics, design, and operating problems relating to public utilities operating in small metropolitan areas, with medium- or low-density load areas and extensive transmission." The Program Committee has been in contact with Institute headquarters and with prominent men in the area and is working out a program which should be both interesting and enlightening. The nearness of Jackson to the University of Michigan and Michigan State College, as well as several universities in the City of Detroit, lends itself very readily to student activities. A number of student sessions with some very interesting student papers are included in the program and a large student representation is expected from the entire area. There will be sessions for graduate students' papers on the first afternoon and sessions for undergraduate students' papers on the second day. An inspection trip to either the University of Michigan or the Michigan State College campus is contemplated, and every effort will be made to arrange this trip. Both have new Electrical Engineering buildings which will be interesting.

A student banquet and a student luncheon will be held also. However, these will not conflict with the main banquet at which a large attendance from the student group is expected.

ENTERTAINMENT

The evening program of entertainment will include the main banquet on May 11, and a speaker of national prominence has been promised for this occasion. Every effort is being made to have the Illuminated Cascades, for which Jackson is noted, lighted and in operation in the evening after the banquet, so that those attending the meeting may have the pleasure of viewing this illuminated waterfall, which is the only one of its kind in the United States. This waterfall operates usually from Memorial Day through Labor Day, but a trial run is usually scheduled for mid-May to determine that everything is in working order. The committee is making every effort to have this trial scheduled for one of the nights of the meeting.

Michigan rates as one of America's leading industrial areas and, as a result of its many attractive features to industry, has many and varied plants. Inspection trips are being scheduled to some of these plants which are within a reasonable radius of Jackson. Tentative possibilities of inspection trips to such plants include the Clark Equipment Company factory and substation, manufacturer of transmissions; Goodyear Tire Factory; one of the food plants in Battle Creek; the new B. E. Morrow Steam Plant of Consumers Power Company; the new Bridgen Substation, and the Battle Creek Hydro Plant. The Battle Creek Hydro Plant is one of the oldest hydro plants in service, having a generator driven by a flat belt. There are numerous automobile plants and automobile parts plants in the vicinity, some of which may be included in the agenda for inspection trips. The Sparton Radio Plant is located in Jackson, and, likewise, may be included. Detroit is within easy access of the meeting city and tentatively, consideration is being given to an inspection trip to see the 100,000-kva transformer at the Detroit Edison Superior Substation through which interconnection is made to the Consumers Power Company system. Four 18-hole golf courses are available for those who are so interested in the activity.

Arrangements are being made for a complete program of entertainment for the ladies, which will include a luncheon, a sight-seeing trip, card games, golf, and other entertainment, besides attendance at the main banquet on the evening of May 11. A very capable committee, headed by Mrs. E. V. Sayles, is doing everything to make this District meeting one long to be remembered by those ladies who attend.

HOTEL RESERVATIONS

Members planning to attend the Great Lakes District Meeting are urged to make hotel reservations now, or as early as possible to be sure of accommodations. The committee, likewise, states it will be necessary, where possible, to double up in rooms and that the reservation may be made that way. Blocks of rooms have been set aside at the Hotel Hayes and the Otsego Hotel. The Otsego Hotel is $2^1/_2$ blocks from meeting headquarters. However, some of the activities are scheduled for meetings in this hotel.

Reservations must be made before May 1, 1950, and request for reservations should be sent directly to the hotel of choice, but only to one hotel. A copy of the request should be sent to H. R. Wall, Chairman, Hotel Reservations; care of Commonwealth Associates Incorporated, Jackson, Mich. If accommodations are not available at the hotel of choice, the Hotel Reservations Committee will arrange for transfer of the request to the other hotel. Room rate schedules for the two hotels are as follows:

Hotel Hayes

Single room	$4.50
Double room	6.50
Twin	7.50
Suite	8.00 and 9.00

All with combination tub and shower

Otsego Hotel

Single with bath	$4.00, 4.50, 5.00
Double with bath	5.00, 5.50, 6.50
Twin with bath	6.50, 7.50, 8.00
Single without	2.75, 3.00
Double without	4.00, 4.50

Members of the AIEE Great Lakes District Meeting Committee are, seated left to right: A. W. Rauth, Vice-Chairman; J. R. North, Committee at Large; F. G. Boyce, Committee at Large; Mrs. E. V. Sayles, Ladies Activities; E. F. Dissmeyer, Advisory Committee. Standing, second row: E. S. Jackson, Publicity; B. P. Carr, Transportation; G. Strelzoff, Student Activities; B. S. Moulton, Entertainment and Sports; W. E. Jacobs, Inspection; F. E. Davis, Secretary. Standing, back row: I. B. Baccus, Advisory Committee; M. W. Balfour, Program; F. VonVoigtlander, Information; H. W. Hartzell, Contact; L. W. Robinson, Finance, and J. S. Francis, Registration. Absent from photograph are C. D. Malloch, General Chairman; J. H. Foote and E. V. Sayles, Committee at Large; O. E. Bowlus, Advisory Committee; and H. R. Wall, Hotel

Official Nominees Announced for 1950 AIEE National Election

Titus G. LeClair, Assistant Chief Electrical Engineer, Commonwealth Edison Company, Chicago, Ill., was nominated for the AIEE presidency by the Nominating Committee at its meeting held in New York, N. Y., January 31, 1950. Others named on the official ticket of candidates for the Institute offices that will become vacant August 1, 1950, are

For Vice-Presidents

J. G. Tarboux, Professor and Assistant Director, School of Electrical Engineering, Cornell University, Ithaca, N. Y. (North Eastern District, number 1)

C. S. Purnell, General Industry Supervisor, Industrial Sales Department, Westinghouse Electric Corporation, New York, N. Y. (New York City District, number 3)

J. R. North, Chief Electrical Engineer, Commonwealth Associates, Inc., Jackson, Mich. (Great Lakes District, number 5)

H. R. Fritz, Chief Engineer, Southwestern Bell Telephone Company, St. Louis, Mo. (South West District, number 7)

J. A. McDonald, Superintendent, Service Shop, General Electric Company, Salt Lake City, Utah (North West District, number 9)

For Directors

Walter J. Barrett, Electrical Co-ordination Engineer, New Jersey Bell Telephone Company, Newark, N. J.

A. G. Dewars, Manager, System Planning, Operating Department, Northern States Power Company, Minneapolis, Minn.

Victor Siegfried, Chief Research Engineer, Research and Development Laboratory, American Steel and Wire Company, Worcester, Mass.

For Treasurer

W. I. Slichter, Professor Emeritus, Electrical Engineering, Columbia University, New York, N. Y.

The Nominating Committee, in accordance with the Constitution and Bylaws, consists of 15 members, one selected by the executive committee of each of the ten geographical Districts, and five selected by the Board of Directors from its own membership.

The Constitution and Bylaws of the Institute require publication in *Electrical Engineering* of the nominations made by the Nominating Committee. Provision is made for independent nominations as indicated in the following excerpts from the Constitution and Bylaws:

Constitution

Section 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the Secretary when and as provided in the Bylaws; such petition for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

Bylaws

Section 22. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with Article VI of the Constitution and sent by the Secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

BIOGRAPHICAL SKETCHES OF NOMINEES

To enable those Institute members not acquainted personally with the nominees to learn something about their engineering careers and their qualifications for the Institute offices to which they have been nominated, brief biographical sketches are scheduled for inclusion in the "AIEE Personalities" columns of the April issue.

Tentative Program Announced for Electric Welding Conference

A tentative program for the Conference on Electric Welding, scheduled to be held April 5–7, 1950, at the Rackham Memorial Building, Detroit, Mich., has been announced. This will be the second welding conference sponsored by the AIEE in cooperation with the American Welding Society and the Industrial Electrical Engineers Society in Detroit. Brief digests of some of these papers will appear in the April issue of *Electrical Engineering*.

Anyone interested in attending this conference may obtain an advance registration card by writing E. D. Kane, Registration Chairman; Detroit Edison Company, 2000 Second Avenue, Detroit 26, Mich., or R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York, N. Y.

Third Conference Scheduled on Rubber and Plastics Industry

The Subcommittee on Rubber and Plastics Industries of the AIEE Committee on General Industry Applications has been actively engaged in working out plans for the third Special Technical Conference on Electrical Engineering Problems in the Rubber and Plastics Industry to be held in Akron, Ohio, May 5, 1950. The conference, as planned, will consist of a morning and an afternoon session. Numerous interesting topics have been suggested for discussion and a committee has been appointed to make a suitable selection of authors and discussers. When the complete program for this conference has been established, it will be announced in a subsequent issue.

Plans Progress for Meeting of North Eastern District

Plans for the 3-day meeting of the AIEE North Eastern District, to be held in Providence, R. I., April 26–28, 1950, are rapidly

Tentative Program

Conference on Electric Welding

Wednesday, April 5

9:00 a.m. Arc Research

L. P. Winsor, Chairman

The Physical Mechanism of Low- and High-Current Arcs and Their Relation to the Welding Arc. *Dr. Wolfgang Finkelnburg*, Fort Belvoir

New Electrodes for Stabilizing Inert-Gas Arc Welding. *Dr. J. D. Cobine, C. J. Gallagher*, General Electric Research Laboratory

The Electric Arc in Argon and Helium. *Dr. J. B. Jones, Merrill Skolnik*, The Johns Hopkins University

The Electron Stream in the Inert-Gas Shielded Arc. *G. K. Willecke*, Miller Electric Company

Characteristics of High Current Density Inert-Gas Shielded Metal Arc. *A. Muller, G. R. Rothschild*, Air Reduction Company

2:00 p.m. Arc Machines

J. H. Blankenbuehler, Chairman

A-C Arc Welders With Saturable Reactor Control. *S. Oestreicher*, Harnischfeger Corporation

Arc Welding Machine Characteristics as They Affect the Welding Arc. *George Wagner*, Bureau of Ships, United States Navy

Welding Characteristics of Mechanical-Rectifier-Type Arc Welder. *K. L. Hansen*, Consulting Engineer, Milwaukee, Wis.

Hydraulic Control of Transformer-Type Arc Welders. *A. C. Mulder, G. K. Willecke*, Miller Electric Company

Thursday, April 6

9:00 a.m. Special Welding Processes

E. M. Guyer, Chairman

Nelson Arc Stud Welding Process. *R. C. Singleton*, Morton Gregory Corporation

Submerged Arc Welding. *J. A. Kratz*, Linde Air Products Company

High-Frequency Induction Welding. *R. J. Bondley*, General Electric Company

Electric Glass Welding. *M. R. Shaw*, Corning Glass Works

Gas Coverage of the Inert-Gas Welding Arc. *R. W. Tuthill*, General Electric Company

2:00 p.m. Instrumentation

R. C. McMaster, Chairman

Measuring Current in Low-Frequency Resistance Welding Converters. *C. B. Stadum*, Westinghouse Electric Corporation

A New I^2T Indicator for Resistance Welding. *N. P. Millar, Algird A. Kavaliauskas*, General Electric Company

Instrumentation for Flash Welding. *Professor R. A. Wyant, Professor Lauriston P. Winsor*, Rensselaer Polytechnic Institute

Instrumentation for Contact Resistance Measurements. *W. B. Kouwenhoven, William T. Sackett*, The Johns Hopkins University

Friday, April 7

9:00 a.m. Resistance Welding Machines

W. G. Bostwick, Chairman

Design of Transformers for Resistance Welding Machines. *Dean L. Knight*, National Electric Welding Machines Company

Multitransformer Welding Presses. *Jack Ogden*, General Motors Corporation. Prepared discussion by: *W. E. Smith*, Midland Steel Products Corporation

Power Supply for Multitransformer Welding Presses. *T. F. Ellis*, Kaiser-Frazer Corporation. Prepared discussion by: *O. J. Marshick*, General Motors Corporation

Ignitrons for Frequency-Changer Welders. *R. R. Rottier*, General Electric Company

2:00 p.m. Power Supply

H. W. Tietze and W. K. Boice, Cochairmen

The Effect of the Duration of Voltage Dip on Cyclic Light Flicker. *Lawrence Brieger*, Consolidated Edison Company of New York, Inc.

Low-Voltage Drop Busway for Welder Feeders. *R. C. Wilson*, Trumbull Electric Manufacturing Company

Probabilities of Interference Between Resistance Welders. *W. K. Boice*, General Electric Company

Welding Power System With Series Capacitors at Main Transformer Primaries. *C. W. Wright*, General Motors Corporation

Future AIEE Meetings

AIEE Conference on Electric Welding
Detroit, Mich.
April 5–7, 1950

AIEE Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
April 13–14, 1950

AIEE Power Conference (Power Generation and Power Supply for Industrial Plants)
Hotel William Penn, Pittsburgh, Pa.
April 19–20, 1950

North Eastern District Meeting
Sheraton-Biltmore Hotel, Providence, R. I.
April 26–28, 1950
(*Final date for submitting papers—closed*)

AIEE Conference on Electrical Engineering Problems in the Rubber and Plastics Industry
Portage Hotel, Akron, Ohio
May 5, 1950

AIEE Conference on Improved Quality Electronic Components
Washington, D. C.
May 9–11, 1950

Great Lakes District Meeting
Hotel Hayes, Jackson, Mich.
May 11–12, 1950
(*Final date for submitting papers—closed*)

AIEE Conference on Telemetering
Philadelphia, Pa.
May 24–26, 1950

Summer and Pacific General Meeting
Huntington Hotel, Pasadena, Calif.
June 12–16, 1950
(*Final date for submitting papers—March 14*)

Middle Eastern District Meeting
Lord Baltimore Hotel, Baltimore, Md.
October 3–5, 1950
(*Final date for submitting papers—July 5*)

Fall General Meeting
Skirvin Hotel, Oklahoma City, Okla.
October 23–27, 1950
(*Final date for submitting papers—July 25*)

1951 Winter General Meeting
New York, N. Y.
January 22–26, 1951
(*Final date for submitting papers—October 24*)

View down College Hill from Brown University toward main business section of Providence, R. I., site of the AIEE North Eastern District Meeting, April 26–28

nearing completion. Eight technical sessions and conferences are tentatively scheduled. Meeting headquarters will be in the Sheraton-Biltmore Hotel. Located on Narragansett Bay, Providence is the center of the jewelry industry and home of Brown University.

On the opening day the committee has arranged a bridge and tea as a get-together event for the ladies. In addition, suitable entertainment and inspection trips are also being arranged for the ladies attending the meeting.

There will be a banquet on the first evening for all those attending the meeting, to be followed by an informal get-together and entertainment on the second evening of the meeting.

For convenience in arranging for a room reservation, the room rate schedule for the Sheraton-Biltmore Hotel is as follows:

	One Person	Two Persons
Rooms with double bed		
With tub bath	From $4.00	$6.50
With tub and shower	From 5.75	8.25
Rooms with twin beds		
With tub bath	From 5.75	8.75
With tub and shower	From 6.25	8.75
Salon suites, parlor and bedroom—$18.00 per day.		

Early requests for hotel accommodations are urged.

Conference on Telemetering to Be Held in Philadelphia

The special technical Conference on Telemetering, sponsored jointly by the AIEE Joint Subcommittee on Telemetering and the National Telemetering Forum, will be held May 24–26, 1950, at the Benjamin Franklin Hotel in Philadelphia, Pa. The Philadelphia Section of the AIEE will act as host.

This conference is to serve as a background for exchanging points of views and terminology of mobile radio and point-to-point telemetering systems. A full program of papers and inspection trips, correlated with the subject, is being planned.

The officers of the conference are: Chairman W. J. Mayo-Wells, Applied Physics Laboratory, Johns Hopkins University; Vice-Chairman G. M. Thynell, The Bristol Company; Secretary F. L. Verwiebe, Applied Physics Laboratory, Johns Hopkins University; Treasurer M. J. A. Dugan, General Cable Corporation; Program, P. A. Borden, The Bristol Company; Publications, E. E. Lynch, General Electric Company; Local Arrangements, W. E. Phillips, Leeds and Northrup Company; National Publicity, J. L. Blackburn, Westinghouse Electric Corporation.

1951 Summer General Meeting Committee. According to a recent announcement, the following have been appointed members of the General Committee to make plans for the AIEE Summer General Meeting which is to be held in Toronto, Ontario, Canada, June 25–29, 1951:

O. W. Titus, *Chairman*, J. T. Fisher, D. G. Geiger, W. J. Gilson, W. R. Harmer, M. C. Thurling, J. T. Thwaites.

Interesting Inspection Trips Scheduled for Summer Meeting

According to a recent announcement, a tour of the Walt Disney Studios will be only one of many interesting inspection trips which are being planned for the coming AIEE Summer and Pacific General Meeting. This meeting will be held in Pasadena, Calif., June 12–16, 1950.

Included also on the inspection trip schedule will be the world's largest telescope at Palomar; authentic Mexican atomosphere and entertainment at Padua Hills; the excitement of Hollywood; and Mt. Wilson, high above Pasadena and Los Angeles. In addition, a number of trips are planned which will be of interest from an industrial and power generation standpoint.

Conferences on Textile Industry Scheduled for Atlanta, Providence

The Textile Subcommittee of the AIEE Committee on General Industry Applications has been busily engaged in working out plans for and the details of the programs for the Southern and New England Conferences on Electrical Application for the Textile Industry, which will be held respectively in Atlanta, Ga., April 13–14, 1950, and in the morning of one of the days of the North Eastern District Meeting, in Providence, R. I., April 26–28, 1950.

The Southern conference will consist of a morning and afternoon session on the first day, in addition to a luncheon with talk by Dr. H. A. Dickert, Director of A. French

Oklahoma City Oil Fields

These oil wells, as seen from the steps of the Oklahoma State Capitol, are part of an oil field which extends through the middle of Oklahoma City and for about 20 miles north of the city. Third largest producing oil field in the world and still expanding, this field is scheduled for inspection during the AIEE Fall General Meeting which will be held in Oklahoma City, October 23–27, 1950

Textile School of Georgia Institute of Technology, and a morning session on the second day. The New England conference will consist of one morning session, which will be held on one of the days of the North Eastern District Meeting.

Every effort is biing made to have a large attendance at the Southern conference and the subcommittee has been contacting the textile executives of Georgia, Alabama, the Carolinas, and Tennessee. Complete programs of both conferences will appear in the "Institute Activities" section of the April issue of *Electrical Engineering*.

Record Technical Program Featured at Winter General Meeting in New York

Marked by a technical program surpassing in scope even last year's unprecedented Winter Meeting program, the AIEE Winter General Meeting for 1950 was held in New York, N. Y., January 30–February 3. Again, as last year, to provide for the greater convenience of the more than 3,200 members and guests attending the meeting, headquarters were set up at the Hotel Statler with its many facilities for both technical and social activities.

The diversity and interest of the technical program was well attested to by the gratifying attendance at the 57 different technical sessions and conferences. Offering a total of some 227 papers, this program was the result of the efforts of the Institute's 39 technical committees working through its five technical groups: Communication, General Applications, Industry, Power, and Science and Electronics. As instituted last year, a nominal registration fee of $3 was required of members and $5 of nonmembers as a step toward making the meeting self-supporting.

With technical subjects ranging from transformers to high-frequency measurements, from fluorescent lighting to electric welding, almost every topic of professional interest to an electrical engineer was covered in the technical sessions. On Thursday, February 2, the AIEE Board of Directors met in an all-day session at Institute headquarters, and during the course of the week a number of AIEE administrative and technical committees held meetings either at the Hotel Statler or in the Engineering Societies Building. Brief reports of a number of these sessions are included in the following pages.

GENERAL SESSION

The general session on Monday afternoon, January 30, featured addresses by Harold E. Stassen, President of the University of Pennsylvania, and Sir Ernest Benn of London, England (in absentia), and the induction of Vannevar Bush, President of the Carnegie Institution of Washington, D. C., as an Honorary Member of AIEE, the eighth in the history of the Institute. The session was presided over by AIEE President James F. Fairman.

"Why Go the Way of Britain?" was the theme of the opening address by Sir Ernest Benn, a recording of which was played for the audience in Sir Benn's absence. Sir Benn decried the effects of current socialistic trends in Britain and warned the United States that this country will meet the same doom if we, like the English, "rely upon politics and collective action to relieve us of the normal and natural responsibilities of healthy men." He pointed out that under Socialism there is a tendency to think of a job in terms of wages rather than in terms of work done and the quality achieved, and that thus personal initiative and, in the final analysis, personal character, are destroyed. The substitution of the collective for the individual, he believes, is the replacement of the enormous constructive and creative natural power of self-interest by a planned and manufactured force which cannot help but engender laziness and dishonesty.

The second item on the program was the conferring of Honorary Member status upon Dr. Bush who was introduced by President Fairman with an outline of his illustrious career in the Institute since becoming an Associate in 1915. Dr. Bush responded briefly, expressing his thanks for the honor bestowed upon him and his joy at being "back among friends."

Declaring that you cannot develop an economic system unless you take due account of the fundamentals of human nature and the basic philosophy of our way of life, the University of Pennsylvania's Harold E. Stassen, former governor of Minnesota and a figure in national politics, pointed out in his address that man requires an incentive or reward for his productive efforts, and, conversely, some penalty or loss for laziness or loafing. He showed that in England today under a socialistic form of government, even with a larger labor force producing, the results are less per man-hour than before the war, and he urged employers to bring these lessons in economic and social fundamentals to their workers by a simple repetition of fundamental facts. For example, a worker in an electrical manufacturing company in America can acquire the necessities of life for about one-third the hours of work than can a similar worker in any other electrical manufacturing plant in the world.

Full texts of both Mr. Stassen's and Sir Benn's addresses are scheduled for early publication in a forthcoming issue of *Electrical Engineering*.

ETA KAPPA NU AWARDS

Eta Kappa Nu Recognition Awards to outstanding young engineers in the United States for 1949 were presented at a dinner at the Henry Hudson Hotel on Monday evening, January 30 (*EE, Feb' 50, p 178*). The first-prize award went to Robert Chase Cheek of the Westinghouse Electric Corporation, while Lester M. Field, Stanford University, and Louis G. Gitzendanner, General Electric Company, received honorable mention. Biographies of AIEE members Cheek and Gitzendanner appear elsewhere in this issue (*p 279*).

Also honored at the Recognition Award dinner were Vannevar Bush; Royal W. Sorensen, Professor of Electrical Engineering at California Institute of Technology; and Vladimir K. Zworykin, Radio Corporation of America; who were inducted into Eta Kappa Nu as eminent members of the so-

ciety. C. A. Powel, Massachusetts Institute of Technology, acted as toastmaster for the occasion and Dr. A. S. Adams, President of New Hampshire University, was the principal speaker.

ENTERTAINMENT

As usual, the smoker at the Hotel Commodore on Tuesday evening and the dinner-dance at the Statler on Thursday evening vied in popularity. In addition, members and guests were able to reserve seats at several shows and to obtain tickets for a variety of broadcasts throughout the week. Also available were reduced rate tickets for the Empire State Observatory and the Radio City Tour.

A busy and entertaining week was planned for the ladies attending beginning with a "Get-Acquainted Tea" on Monday afternoon. On Tuesday, the ladies were given a luncheon and tour of the Consolidated Edison Waterside Station and in the evening a dinner and bridge was held at the Engineering Women's Club on lower Fifth Avenue. Wednesday was devoted to a motor tour to the United Nations, and on Thursday a luncheon and fashion show were held in the Terrace Room of the Plaza by courtesy of the General Electric Company. The main event on Friday was the *S. S. America* tour. Chairman and Vice-Chairman of Ladies Entertainment were, respectively, Mrs. D. A. Quarles and Mrs. G. T. Minasian. They were aided by the following ladies: Mrs. E. S. Banghart, Mrs. W. J. Barrett, Mrs. F. S. Black, Mrs. R. F. Brower, Mrs. O. E. Buckley, Mrs. J. L. Callahan, Mrs. A. J. Cooper, Mrs. A. F. Dixon, Mrs. R. W. Gillette, Mrs. C. T. Hatcher, Mrs. N. S. Hibshman, Mrs. R. K. Honaman, Mrs. A. E. Knowlton, Mrs. G. J. Lowell, Mrs. R. F. Miller, Mrs. R. T. Oldfield, Mrs. R. J. Talley, III, Mrs. D. W. Taylor, and Mrs. C. H. Willis.

INSPECTION TRIPS

The schedule of inspection trips, arranged to carry out as far as possible the subject matter of the various technical sessions, proved as popular as ever with the membership. The tours of the Sewaren Generating Station of the Public Service Electric and Gas Company (450,000 kw) on Tuesday and of the United States Lines *S. S. America* on Friday attracted the heaviest registration. However, all of the trips were very well attended. These included the Radio City Music Hall's backstage electric and mechanical equipment; Long Distance Headquarters of the American Telephone and Telegraph Company; Esso Bayway Refinery and Research Center of the Standard Oil Company of New Jersey; The *New York Herald-Tribune* publishing plant; United States Signal Corps Engineering Laboratories at Fort Monmouth, N. J.; the Western Electric Company's Cable Plant; and *WOR-TV*'s television transmitter and television studio.

TELEVISION EXHIBIT

A technical exhibit showing the progress of a television image from the camera to the home was featured in the Penn Top Room of the Hotel Statler. The exhibit, which was originally shown at the Hotel McAlpin by the New York Section of the AIEE during the 116th Annual Meeting of The American Association for the Advancement of Science, December 26–31, 1949, included a television camera in action with a monitoring receiver in which guests at the exhibit could see themselves through the camera's eye; and a large-scale model of a television transmitting station complete with studio. Various phases of television transmission and reception were dramatized by the exhibits, ranging from cathode-ray tubes to an historical display of receiving antennas.

CONFERENCE PAPER DIGESTS

Short authors' digests of most of the conference papers presented at Winter Meeting sessions are included in this issue (*pp 250–64*). The customary one-page digests of the technical program papers will appear in succeeding issues of *Electrical Engineering*.

Discussion of Finances Included at Meeting of Sections Committee

At a meeting of the AIEE Sections Committee held on January 31, 1950, during the Winter General Meeting, the following subjects were discussed:

1. Changes in Section territories.
2. Institute and Section finances.
3. Institute and Section publicity.
4. Section operation and management.
5. A preliminary report on membership opinion on Institute policy.

C. S. Purnell, Vice-Chairman of the Sections Committee, presided at the meeting.

CHANGES IN SECTION TERRITORIES

The background and territory assignments that led to the petition for the establishment of Section status for the proposed North Eastern Michigan Section were described by J. F. Dexter III. His remarks were supplemented by E. L. Holmgren, Chairman of the Saginaw Valley Subsection. On a motion by E. F. Dissmeyer, Chairman of the Michigan Section, which was seconded by George W. Bower, the Sections Committee voted to recommend to the Board of Directors that the Saginaw Valley Subsection of the Michigan Section be granted Section status with the name of North Eastern Michigan Section and that its territory include certain counties all in the state of Michigan and now a part of the Michigan Section. The recommendation was approved subsequently by the Board of Directors at its meeting on February 2.

A proposal to change the name of the Northern New York Subsection of the Syracuse Section and reassign the counties of Essex, Franklin, and Clinton now assigned to the Schenectady Section, together with the counties of Stormont and Glengarry, now respectively assigned to the Ottawa Section and the Montreal Section, to form a new St. Lawrence International Subsection was outlined by Victor Siegfried, Vice-President of District 1 and A. H. Frampton, Vice-President of District 10. The matter was referred to the Board of Directors on motion by J. B. Pitman, Chairman of the Northern New York Subsection, which was seconded by G. W. Bower. Subsequently, the Board of Directors approved the recommendation.

The Sections Committee also reaffirmed its resolution, adopted last summer, to the effect that the Vancouver Section be transferred from District 10 to District 9. The Board of Directors at its meeting on February 2 authorized the transfer of the Province of British Columbia from District 10 to District 9 and a travel allowance for the Vice-President of

Vannevar Bush (right), President, Carnegie Institution of Washington, receives a certificate of AIEE Honorary Membership from AIEE President James F. Fairman at the Winter Meeting general session on Monday. Looking on is Harold E. Stassen, President of the University of Pennsylvania, principal speaker of the afternoon

District 10 to visit the Vancouver Section once each year to maintain a contact of purely Canadian interests; this travel allowance to be computed from the closest Section or Branch in District 10. The matter of such a travel allowance is to be reviewed at the end of two years to determine whether or not its continuance is desirable.

INSTITUTE FINANCES

The trends in Institute finances were reviewed by E. P. Yerkes, Chairman of the Finance Committee. He said that the budget was nearly $900,000 per year, and that last year was closed with a slight surplus. The Finance Committee borrowed $3,000 from the surplus to put the budget for the current year in balance. He explained that the income trend and the expenditure trend was upward with expenditures rising at a steeper rate. He referred to the efforts to keep activities which benefit only a part of the membership on a self-supporting basis such as the registration fees at meetings; the sale of preprints; and, in respect to the sale of *Transactions*, the effort to set a price that will compensate for the cost of those publications. He pointed out that the technical conferences were conspicuously successful in that they resulted in no expense to the Institute. Until now, the Year Book had been distributed free, but there was some question as to whether it was proper or wise to charge for it. The revenue from advertising had been increased through raising the rates and there has been an effort to stimulate the matter further.

On the expense side, Mr. Yerkes referred to the salaries of the Headquarters staff, and he complimented Mr. Henline, the Secretary, in that the Institute gets more done than many of the other societies, which is a remarkable praiseworthy performance. With respect to travel allowances, he pointed out that the Finance Committee has the responsibility of making a recommendation to the Board of Directors again as there are many whose travel expenses are not compensated. The cost of prizes has tended to increase in recent times since the revision of the rules with the award of more prizes than heretofore. The publication expense had been going up and other publishers have found it necessary to raise their prices. He referred to the need to increase the Headquarters expense for the benefit of the staff such as to improve illumination and the question whether to partially or completely air condition Headquarters. He also explained that the cost of supporting the retirement system would tend to increase as time went on.

ADVERTISING INCOME FROM ELECTRICAL ENGINEERING

A study of this matter which had been made by a subcommittee was outlined by J. C. Strasbourger. The subcommittee recommended and the Sections Committee approved a suggestion that a competent advertising solicitor be hired to supplement the present staff, and that the desirability of revising the rate schedule of present advertising should be carefully reconsidered. The suggestions were made in the belief that the income from advertising should cover the full cost of the publication and distribution of *Electrical Engineering*. As a matter of information, it was pointed out by R. K. Honaman that the advertising rates had been raised during the past few years, and that the rates are now as high as the market will support. The Board of Directors, at its meeting on February 2, referred the recommendation to the Publication Committee for further study.

DISTRIBUTION OF THE YEAR BOOK

A study made of the matter by a subcommittee was reported by J. C. Strasbourger. The study concerned the distribution of the Year Book and the suggestion that it be sent free-of-charge to officers and chairmen and secretaries of committees in Sections, but be sold to members and others. The Sections Committee approved the report and recommended to the Board of Directors that any Institute member, whether or not he is a committeeman, should be privileged to acquire a copy of the Year Book without charge for use in Institute activities. The additional revenue from the sale of the Year Book to members would be negligible and the Institute should continue the present policy of distribution, including free copies to members for Institute use on request and to public libraries. The Year Book should be sold to nonmembers and commercial organizations at a suggested price of $5. Subsequently, the Board of Directors referred the matter to the Publication Committee for further study.

SECTION FINANCES

The report of the Special Subcommittee on Section Finances was given by G. W. Bower, Chairman. He said that 30 out of 36 Sections reporting found that they could live within their present allotments and that two other Sections reported small deficits. The Sections with Finance Committees get along very well and they keep track of expenditures monthly. The expense of meeting notices can be kept down by combining or using council notices for the area. Mailing expense can be decreased by using bulk mailing to colleges, lower postage rates, or the use of post cards. In conclusion, he suggested that every Section representative bear in mind that anyone can spend money and the Sections can help in doing a good job by keeping within their allotments.

INSTITUTE AND SECTION PUBLICITY

The objectives of Institute and Section publicity were explained by R. K. Honaman, Chairman of the Committee on Public Relations. The Institute is doing a good job and must see to it that it is recognized by an interested public. The Institute is getting, through the press and current publications, more publicity than ever before, and that is the job of getting recognition for the engineer. It is the job of explaining what engineers have contributed to the modern American engineering organizations. Several of the Sections reported good results through the use of the publicity kit, and the importance of appointing people with publicity experience to handle publicity was emphasized.

The suggestion was made by H. A. Dambly of the Philadelphia Section that the importance of television with its 2,400,000 sets should not be overlooked as a possible channel for publicity, and it was explained that something would be added to the publicity kit on television.

Each of the publications of the Institute (preprints, *Proceedings*, *Transactions*, *Electrical Engineering*, and special publications) were briefly described by K. B. McEachron, Chairman of the Publication Committee. He assured the audience that no subject was more controversial than publications, and he explored ways in which the Sections might be of assistance. With respect to the question of dividing the *Transactions* into subject divisions, he explained that present binding costs were approximately $1.40 per volume. The committee is exploring the possibility of issuing a card subscription for subject divisions of the *Proceedings*, and with the proceeds, send out subject divisions to subscribers periodically.

With regard to the one-page digests of technical papers in *Electrical Engineering*, Dr. McEachron pointed out that there is a segment of people who would prefer shorter abstracts of eight or ten lines. Another substantial segment of people prefer the one-page digests as published at present. In this respect, the people in the Sections can be of assistance in determining the views of others in their Sections.

With regard to the special publications, Dr. McEachron explained that these were very important to a highly specialized or small segment of Institute membership.

MEMBERSHIP OPINION ON INSTITUTE POLICY

A preliminary report on membership opinion on Institute policy was given by M. D. Hooven, Chairman of the Special Committee of the Board of Directors. He outlined the origin of the assignment, and the responses received from the various Sections to the two questions which appeared in the October 1949 issue of *Electrical Engineering*. Almost 10,000 people had expressed themselves, which represents a remarkable return of about 30 per cent; professional polls are considered quite good if in excess of 23-per cent return. The complete report and the results appear in the President's Message for this issue on pages 191–4.

COMPARATIVE RATING OF SECTION OPERATION

C. G. Veinott, Vice-President of District 2, explained a novel system of rating of Sections which had been tried out experimentally in the District to stimulate activity. He said that in the last analysis the health of the Section is determined by its members and the turnout for meetings, and that the problem is how to measure the growth. If any of the territory or members were transferred from one Section to another, they were not counted in either Section. As a reward, it was not planned to ask for more funds, but to issue a suitably engraved certificate with adequate publicity.

MEMBERSHIP

The Chairman of the Membership Committee, F. S. Black, told how his committee had set up a procedure where students could apply for membership before leaving college, and that 2,200 or 2,300 students have applied. He urged that everything be done to make sure that these new members are welcomed by the Section chairmen.

In connection with the 5-year estimates, Mr. Black explained that the Membership Committee had estimated that by 1954 the AIEE would have 45,000 members, and by May 1, 1950, it would have 34,500. On January 1, the Institute had 34,000 members, and it has been growing at a little more rapid rate than expected.

MEMBERSHIP GRADE TRANSFERS

A proposal for a manual or guide for the Sections Committees on Transfers and the publicizing of the higher grades of membership were advocated by F. W. Willcutt, Chairman of the Committee on Transfers. He explained that the truly professional grades are Member grade and Fellow grade, accounting for 32 per cent of the membership, and that although the Institute is glad to have the Associates, nevertheless accountants, foremen, and so forth, could qualify as Associates. The impetus of the transfer to higher grade should come from the local Committees on Transfers in the Sections performing the initial screening and the initiative is in the hands of the local committees.

STUDENT BRANCH CO-OPERATION

Professor F. O. McMillan, Chairman of the Committee on Student Branches, briefly reported on the intersociety work going on in connection with the Branches. Last year, the American Society of Civil Engineers suggested that the societies with chapters and branches in the same school get together, and an exploratory meeting was held on September 12, followed by another meeting more recently; a complete report will be made later. The primary outcome seemed to be that the various societies feel that there is a need for the branches to get together. Professor McMillan advised that President Fairman's address, "Professional Unity at the Grass Roots" (*EE, Dec '49, pp 1021–3*), which suggested that there should be an over-all society in the schools to develop the professional aspects of engineering, had been very well received.

EDUCATIONAL ACTIVITIES

The Chairman of the Committee on Education, Professor B. R. Teare, Jr., reported that his committee and the Engineers Council for Professional Development has been studying the problem of getting young engineers started in industry. He drew attention to the titles of the five papers and authors which were presented in a conference on education, February 1, with A. C. Monteith presiding (*p 274*).

New Electronic Devices Subject of Conference Papers

Four conference papers covering developments in the electronics field were presented on the opening day of the Winter General Meeting, January 30. The variety of the subjects covered made for an interesting session, over which William C. White of the General Electric Company presided.

The papers were timely in that they reflected the trend of the art. "Magnet Current Regulators," by C. A. Black and H. A. Gauper, discussed equipment designed to maintain the current in a cyclotron constant, so that the resulting flux varied only one part in 10,000.

The fact that electronics plays a major role in manufacturing was emphasized in the paper, "Optical Contour Follower Control for Machine Tools," by T. M. Berry of the General Electric Company. One part of this apparatus follows any irregular curved outline and transfers the exact movements of the curve follower, in a reduced form if desired, to a mechanism for cutting a template. For example, the cost of thus reproducing a master has been reduced approximately 75 per cent and the time has been reduced in the same proportion.

Other papers presented at this session were "Magnetic Modulation of Photocurrents and Its Application," by H. P. Kalmus of the Bureau of Standards and "Manufacture of Electron Tube Parts by the Rubber-Die Technique," by W. J. Bachman of the Radio Corporation of America.

Transformer Noise Main Concern of Transformer Session Papers

The problems of measuring and minimizing noise from transformers were presented in five papers in a session on Transformers, January 30, with J. H. Chiles, Jr., presiding. The problem has become of more importance with the increase in load densities and the need to replace smaller with larger transformers, particularly in residential areas. The author of the first paper, T. D. Gordy of the General Electric Company, explained that the principal source of noise comes from magnetostriction in the core and the noise is increased with peaked frequencies. Noise may be decreased by the use of internal and external barriers or changing the core material. The operating companies are faced with two alternatives: either to purchase more expensive low noise-level transformers or to enclose transformer installations totally. Close co-operation was suggested between operating companies and the manufacturers working through organizations such as the AIEE.

The paper on a harmonic index as a tool for transformer audio noise investigation was presented by W. H. Mutschler, Jr., of the Allis-Chalmers Manufacturing Company. The harmonic index is actually a measure of frequency to the ear, and in the presentation, the author demonstrated that noises generated at low frequencies are less objectionable than those generated at higher frequencies.

The third paper, "Audio Noise in Transformers in Residential and Commercial Areas," by C. E. Baugh of the Pacific Gas and Electric Company, was presented by L. F. Hunt, and it reported on conditions in that area. He explained that the use of newer core materials with higher flux densities resulted in noisier units, and that walls around the property lines did little good. He pointed out that no complaints with sound levels below 54 decibels had been received, and that units with 52 decibels or lower ratings caused no trouble. If sound levels cannot be improved, the usefulness of distribution substations in residential areas will disappear. The next speaker, A. J. Maslin of the Westinghouse Electric Corporation, analyzed the complex functions of materials, fluxes, and designs to decrease noise as well as the economics of the remedies. He substantiated the fact that roofless or partial enclosures are less effective than total enclosures.

The last paper was presented by I. S. Mendenhall who described and illustrated the construction and precautions taken at substation properties adjacent to residential areas in the vicinity of Detroit.

Industrial and Feedback Control Considered in Two Sessions

The newly-organized Feedback-Control Systems Committee made its first appearance in joint session with the Industrial Control Committee on January 30. The results of studies made on two types of magnetic-fluid clutch servomechanisms by A. J. Parziale and P. C. Tilton at the Massachusetts Institute of Technology Servomechanisms Laboratory were presented by Mr. Parziale. One of the clutches studied was an experimental model designed by the authors so that many adjustments could be made in testing. The second clutch studied was a Model *731* made by the Raymond Engineering Laboratory. Tests made on the clutches included the study of characteristics when used alone and when two clutches were driven in opposite directions to provide a reversible servomotor. Tests made using different mediums to bear the magnetic particles showed that the magnetic shear stress was not affected by the fluid characteristics.

H. F. Storm of the General Electric Company presented his paper, "Speed Response of Saturable Reactors." For steady-state operation, the control current of the saturable reactors in a feedback system using two saturable reactors is not dependent on the line voltage. Contrary to general belief, it was demonstrated that the inductance of the control circuit is not dependent on the inductance of the saturable reactors but varies with the load resistance and inversely with the frequency. As the time constant equals L_c/R_c it varies in the same manner.

"An Electronic Synchronous Speed Regulator," by W. J. M. Moore, National Research Council, described a regulator for a d-c motor driving an a-c generator which maintained the frequency of the alternator output in synchronism with a low-power frequency source.

The report of the AIEE Subcommittee on Terminology and Nomenclature of the Feedback Control Committee was submitted by S. W. Herwald, Westinghouse Electric Corporation. Functional block diagrams, junction-point blocks, nomenclature, and symbols were studied and standard forms for each were discussed. Block diagrams were used which could be simplified or amplified to fit most feedback problems. Junction-point blocks are used to indicate arithmetical operations. Nomenclature was chosen to describe the signals and characteristics of the elements involved; and letter symbols that were the initial letters of the terms involved were chosen wherever possible. Greek letters were eliminated so that the system would be easy to type, and the use of subscripts was limited.

The second meeting of the Feedback-Control Systems group on Tuesday, January 31, covered applications of feedback-control systems. "An Air-Borne Synchronized Motion Picture Camera Recording System," by V. J. White and S. J. Horwitz of Northwestern University, was presented by Miss White. It described an air-borne system for obtaining motion pictures of 20 frames per second synchronized within ± 0.002 second for 17 cameras in the parent aircraft and five radio-controlled cameras in a remote ship. "A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms," a study made in the Massachusetts Institute of Technology Servomecha-

nisms Laboratory, was presented by R. J. Kochenburger of the University of Connecticut. A. P. Nottoff of the General Electric Company discussed the introduction of techniques for minimizing the sensitivity of networks which impress the modulated error signal upon a network which operates upon the carrier frequency and its side bands to give modulation in his paper, "Phase Lead for A-C Servo Systems With Compensation for Carrier Frequency Changes."

Enthusiastically received was the Spirule, a plastic calculating gadget, introduced by W. R. Evans of North American Aviation, Inc., in his presentation of "Control System Synthesis by Root Locus Method." G. Kronacher, formerly of General Electric Company, discussed the calculation of inherent errors of generator and control-transformer with respect to the design data in his paper, "Static Accuracy Performance of the Selsyn Generator Control-Transformer System."

Longer Tubes Are Here to Stay, Fluorescent Lamp Session Shows

Which is the preferable lighting installation? Two 4-foot fluorescent lamps or one 8-foot tube? Opinion favored the longer model at the Monday morning Winter Meeting session on Developments in Long-Tube Fluorescent Lighting, presided over by E. H. Salter of the Electrical Testing Laboratories, New York, N. Y.

First speaker at the symposium, which was held in the Hotel Statler's Keystone Room and attended by over 40 engineers, was T. C. Sargent of Sylvania Electric Products, Inc. Mr. Sargent, whose topic was "Long Tube Lamp Trends," preferred the 8-foot length because less physical structure is required.

Less brightness and glare was claimed for the longer lamp by B. F. Greene, Electrical and Lighting Consultant, New York, N. Y., who spoke on "The Installation and Application of the Long-Tube Lamp."

The 96-inch variety is cheaper to maintain, stated H. P. Steele of the Benjamin Electric Company, Des Plaines, Ill. Speaking on "Fixture Design as Affected by Long-Tube Lamps," he cited a study of a 10,000-square-foot factory lighting installation. He said that both initial and operating costs for either 4-foot or 8-foot lengths would be approximately the same, the only variable being maintenance expenses. Longer tubes were found five per cent less costly to maintain.

Control equipment for interior installations of the 96-inch tube was discussed by G. C. Harvey of the General Electric Company, Fort Wayne, Ind., in a paper on "Ballast Developments for Long Tube Lamps." According to Mr. Harvey, the cost of a typical 8-foot-tube ballast has been reduced by 20 per cent in the last three years.

Application of Electrostatics to Textiles Demonstrated at Session

Demonstrations of ingenious new techniques in the fields of printing and textiles highlighted the morning and afternoon sessions on Electrostatic Processes, held Tuesday, January 31, in the Hotel Statler.

In the first symposium, presided over by G. W. Hewitt of the Westinghouse Electric Corporation, East Pittsburgh, Pa., a sound color movie and a table-top demonstration were employed by scientists from the Battelle Memorial Institute, Cleveland, Ohio, to illustrate how Xerography works. Made public less than two years ago, this dry printing process is based on electrostatic and photoconductive phenomena. J. J. Rheinfrank, one of the three coauthors of the paper, divulged that photocopying machines employing dry-printing principles have already reached the market. However, the process has not been sufficiently perfected for application to large-scale printing. Also, the technique, while capable of reproducing tonal gradations from black to white, does not yet give as finished a print as does chemical photography. Mr. Rheinfrank stated that the present resolution of Xerographic plates is from six to ten lines per millimeter. His two coauthors were C. D. Oughton and J. P. Ebert, Mr. Ebert assisting in the demonstration.

Fireworks, courtesy of J. O. Amstuz, Behr-Manning Corporation, Troy, N. Y., were seen at the second session on Electrostatic Processes. Small-sized pyrotechnics they were, to be sure; in fact, they were merely sparks flashing between two charging electrodes, which he used to illustrate his paper on "Electrocoating Sandpaper and Textile Fabrics." Longer life for these two materials when they are coated electrostatically was claimed by Mr. Amstuz. Mechanically coated sandpaper, which under certain rigorous tests will last only five minutes, will have a life of one week when sanded between charged electrodes. Textiles flocculated electrostatically wear ten times as long as mechanically coated fabrics.

Reason for the electrostatic method's effectiveness is that the sand or fibers to be deposited are polarized by an electrostatic field. Polarization stands the grains of sand on end so that as the paper passes by, they are impelled into the paper with their sharpest points protruding. Thus, a more abrasive sandpaper. Polarization also accounts for superior fabrics. If the fibers are oriented at right angles to the fabric to be coated, then many more fibers can be applied, giving a heavier longer-lasting material. Biggest problem in making electrostatic coating work, Mr. Amstuz stated, was the development of a satisfactory adhering substance, which would permanently retain the deposited substances.

Other papers heard at the morning session were "Limitations of Electrostatic Separators," by G. W. Penney, Carnegie Institute of Technology, Washington, D. C., and Mr. Hewitt, chairman of the meeting. Mr. Penney spoke. W. B. Dodson of the American Air Filter Company, presented "A Discussion of Methods for the Measurement of Space Charge Density."

In the afternoon, Mr. Penney, Mr. Hewitt's coauthor of the morning, presided. First paper was "Suggested Standards for Electric Power Supplies Used in Electrostatic Precipitation," by W. D. Cockrell and H. V. Nelson of the General Electric Company. Several men commented that this paper represented a good start in a field which has been badly neglected. Mr. Nelson, who spoke for the authors, stated that he welcomed suggestions for improvement as the work represented the thoughts of only a few men. It was requested that a revised paper, incorporating other engineer's ideas, be presented at a forthcoming meeting of AIEE.

The third paper of the second session was "Electrical Precipitators for De-tarring Manufactured Gas," by E. A. Blomquist and A. N. Anderson of the Consolidated Edison Company of New York. Mr. Blomquist was the speaker.

Large D-C Motor Drives Discussed in Four Papers

Four papers were presented concerning large electronic d-c motor drives at a meeting presided over by S. W. Herwald of the Westinghouse Electric Corporation on January 31. The field was summarized by M. M. Morack of the General Electric Company in his paper, "Large Electronic D-C Motor Drives in Industry." O. W. Livingstone, General Electric Company, in a paper entitled "Control of Large D-C Motors Supplied From Ignitron Rectifiers," illustrated the features of the control. He presented a series of slides which showed the evolution of the system from open-loop armature control to the three basic systems; amplidyne amplifier; electronic amplifier; and amplistat, in use today.

"Rectifier Equipment for Electronic D-C Motor Drives," a paper by M. J. Mulhern and S. N. Crawford, General Electric Company, gave a description of the rectifier equipment itself, showed how voltage control was obtained, showed the operation of the amplistat, and described the physical layout of the rectifier. The final paper in this session was "Application of Electronic Motor Drives to Printing Presses," by J. A. Johnson and E. M. Stacey of the General Electric Company. It described the setup necessary for complete electronic control of a modern high-speed metropolitan newspaper press.

Computing Devices Papers Provide Interesting Session

The contents of "giant brains," how they "think," and how they have aided industry from oil refining to aviation were covered in a session on January 31, presided over by J. G. Brainerd of the University of Pennsylvania.

A description of the analogue computer for multicomponent fractionation calculations was presented by G. W. Goelz, coauthor with J. F. Calvert, both of Northwestern University. The second and third papers dealt with the analogue computer for the simulation of airplanes in flight which has attracted country-wide attention at the Massachusetts Institute of Technology. The first of these papers was written by A. C. Hall and the second by C. M. Edwards and E. C. Johnson, Jr., all of Massachusetts Institute of Technology. This computer is of interest inasmuch as dynamic problems of flight, being represented by nonlinear equations, have been solved by it without resorting to "linearized" assumptions.

"The Technique of Handling Power System Problems on a Modern A-C Network Calculator" was the subject of a conference paper by P. O. Bobo of Westinghouse Electric Corporation. He considered the use of

generator reactances in load studies, the representation of power system transformers, system loss computations and loss formulas, and the new procedures resulting from calculating board improvements. In the discussion following this paper, E. T. B. Gross of the Illinois Institute of Technology told about the additions of apparatus to a similar calculator under his supervision and how they facilitated the solutions of more complex problems.

The session concluded with a paper explaining the new techniques on the Anacom, by E. L. Harder and J. T. Carleton of the Westinghouse Electric Corporation.

Papers on Microwaves Cover Communication and Control

Three conference papers were presented at the session on microwave communication and control systems on February 1, of which E. G. Ports of Federal Radio and Telephone Corporation was the chairman.

E. B. Dunn of the Keystone Pipe Line Company in a paper entitled "The Keystone Pipe Line PTM Microwave Link," written in conjunction with A. J. Finocchi of the Federal Telecommunication Laboratories, described the new multiplex communication network now in successful operation in eastern Pennsylvania. The change from the usual telephone to the microwave PTM radio links provides more channels for communication with a minimum of maintenance problems. The same timing system which was described by Mr. Dunn is employed in the power line fault locator which was the subject of a paper presented by R. W. Hughes of Federal Telecommunication Laboratories, Inc., and written in conjunction with N. Weintraub and S. Metzger of the same company. By means of this microwave radio system, the location of a point of trouble in a power line is pin-pointed to an excellent degree of accuracy and with a minimum lapse of time.

"Radio Links for Television" was the subject of the third paper presented by E. M. Ostlund of Federal Telecommunication Laboratories, Inc. He described the microwave equipment used in the 200–300-mile links between cities and the studio-transmitter links, the former being practically automatic in operation. Similar equipment is employed in mobile units to connect remote pickup points with the television studios, the 2,000-megacycle band being used.

Brookhaven Synchrotron Described at Nucleonic Instruments Session

Among the papers which were presented in the Wednesday morning Nucleonic Instrument session with F. J. Gaffney presiding, very great interest was shown in the description of the design of the Brookhaven 2.5-billion-volt proton synchrotron which was presented by Milton G. White, and in the control problems of a power-producing nuclear reactor which was presented by J. M. Harrer of the Argonne National Laboratory.

As chief among the design problems, Mr. White listed the variable magnetic guide field which keeps the protons traveling in an orbit 75 feet in diameter. To produce stable orbits, the magnetic field must have a definitely prescribed radial variation. Stages of the construction work were shown in lantern slides; the heavy engineering phase of the project is scheduled for completion this summer.

In outlining the control problems of a power-producing nuclear reactor, J. M. Harrer explained that in order to prevent dangerously high neutron densities, the control system must include control rods, boron or cadmium, which can be inserted in the reactor rapidly in case neutron density approaches design limits. Control can be accomplished by providing an automatically controlled rod capable of rapid movement, but with limited reactivity so that any neutron density escaped away from the desired power is quickly returned to the control level. For using established servomechanism design techniques and matching a signal from the turbine with a signal from the reactor, he illustrated by diagrams how such a system could be devised.

Other papers which were presented dealt with pulse-amplitude discriminators, nuclear pulses and their amplification, and the equipment for uranium prospecting on foot, by automobile, and with the airplane.

Participating in the medal presentation ceremonies on Wednesday evening of the AIEE Winter General Meeting are shown, left to right: AIEE Secretary H. H. Henline; Edison Medalist K. B. McEachron; D. D. Ewing, who outlined Dr. McEachron's career; AIEE President James F. Fairman; Gano Dunn, who presented a euology on behalf of the late Frank B. Jewett, recipient, posthumously, of the Hoover Medal; Harrison Jewett, Dr. Jewett's eldest son, who accepted the medal for his father; C. E. Davies, Secretary of the American Society of Mechanical Engineers; and J. B. MacNeill, who gave a brief history of the Edison Medal

Edison, Hoover Medals Presented at Ceremonies on Wednesday

On Wednesday, February 1, both the Edison and Hoover Medals were presented, as well as the Institute Prizes for papers, in impressive ceremonies.

The Hoover Medal, which was awarded to Dr. Frank B. Jewett prior to his death on November 18, 1949, was presented to his eldest son, Harrison Jewett, by Colonel C. E. Davies, Secretary of the Hoover Medal Board of Award. On acceptance of the medal, Harrison Jewett said that when his father received notification that he was awarded the Hoover Medal, "he was very much pleased, and was looking forward to this evening." In the ceremonies, Colonel Davies gave the history and the origin of the medal, and Dr. Gano Dunn, who himself was the fourth to receive this high honor and was a life-long friend of the medalist, described Dr. Jewett's career and accomplishments. Dr. Dunn's address appears in full on pages 214–15 of this issue of *Electrical Engineering*.

The Edison Medal was presented to Dr. Karl B. McEachron by President James F. Fairman. In the ceremony, the history and origin of the medal was given by Dr. J. B. MacNeill, Chairman of the Edison Medal Committee. The accomplishments and career of the medalist were given in an address by Dr. D. D. Ewing, Head of the School of Electrical Engineering, Purdue University, who first became acquainted with Dr. McEachron shortly after he enrolled in engineering at Ohio Northern University. After accepting the medal, Dr. McEachron gave an address, "Industry Solves the Lightning Protection Problem." These addresses are published in full in this issue, and will be found on pages 200–05.

The Institute Prizes for outstanding papers presented at its meetings were presented to the winners in five broad classes of technical activity: power, industry, communication, general applications, science and electronics, as well as for the best Student paper. First prize consists of a check for $100 and certificate; second prize of a certificate. The awards were announced by Professor C. H. Willis, Chairman of the Committee on Award of Institute Prizes, and President Fairman presented the prizes to the winners. The names of the winners and the titles of the prize-winning papers appear on page 277 of this issue.

Much Interest Shown in Session on Switchgear

In the session on Switchgear on Wednesday, F. A. Lane presiding, six papers were presented which were widely discussed by well-known operating engineers and design engineers. In regard to a paper on "Outdoor Metalclad Switchgear," many questions were raised by operating engineers in regard to the installation, ease of maintenance, and safety of this type of equipment. In regard to "A New Grounding and Testing Device for Metalclad Switchgear" which was presented by E. T. McCurry, many questions arose concerning the design and safety features. One of the discussors, B. M. Carothers, expressed belief that there was some likelihood that the complexity of the device offsets the effectiveness for which it was intended. In reply to questions raised, one of the authors, H. Krida, explained that all previous designs had been reviewed and as many ideas as possible were obtained from users which resulted in a better device than any previously offered. It was intended to be able to standardize on a single device for general use.

Considerable interest was shown in a paper on "High-Voltage Oil Circuit Breakers for 5,000,000- to 10,000,000-Kva Interrupting Capacity," by W. M. Leeds and R. E. Friedrich of the Westinghouse Electric Corporation. One or two years ago, these interrupting capacities would have been considered impossible. Mechanical features of the circuit breaker were discussed by Phillip Sporn. In the closure, Mr. Leeds explained that the circuit breaker had been tested with 3,000 mechanical operations without getting the cross arm out of alignment, and that attention had been given to assure that bolted parts would remain in alignment. An important paper of a research type on "Operation of Bushings in Carbonized Oil" was presented by L. Wetherill of the General Electric Company and through the knowledge gained from the research, lower maintenance costs may result.

Gas-Filled Thyratrons Considered at Session on Electron Tubes

Under the chairmanship of H. C. Steiner of the General Electric Company, three conference papers and one technical paper were presented at the Gas Conduction Electron Tubes session on February 1 at which gas-filled thyratrons were considered.

M. J. Redden of the United States Bureau of Standards described the equipment used for investigating the cleanup of a noble gas in an arc discharge. He demonstrated that a surprising amount of gas cleanup occurred in the cathode of a thyratron and that the effect of a negative voltage on the probe of his apparatus tended to clean up a large amount of helium, which was the gas used in his investigations. This was in the nature of a preliminary report as studies along this line are being continued, and it was felt that these findings will prove valuable to tube manufacturers.

"Pulse Test Method for Deionization Time Measurement" was the subject of a conference paper by H. H. Wittenburg, Radio Corporation of America. This paper dealt with equipment and method to measure the deionization time. This may be adapted as an AIEE standard method. "The Statistical Nature and Physical Concepts of Thyratron Time" was presented by W. G. Dow, University of Michigan, written in conjunction with H. A. Romanowitz, University of Kentucky.

The final paper in the session was on "Commutation Factor Rating of Inert Gas Thyratrons and Its Influence on Circuit Design," by D. E. Marshall and C. L. Shackelford, both of Westinghouse Electric Corporation. This dealt with the commutation factor rating which specifies to the circuit designer the capability of the tube to withstand positive ion bombardment.

Engineering Education Discussion Occupies Interesting Session

A series of five papers on the education of the engineer after college were presented and discussed at the AIEE Conference on Education, Wednesday, February 1. Those presenting papers were: J. C. McKeon, Westinghouse Electric Corporation, "The Continued Education of the Engineers in Industry"; Guy Kleis, Westinghouse Electric Corporation, and J. S. Cront, Battelle Memorial Institute, "Orientation and Training of the Young Engineer in Industry"; H. L. Solberg, Purdue University, and J. H. Foote, Commonwealth and Southern Corporation, "Professional Registration of the Young Engineer"; A. R. Cullimore and F. N. Entwisle, Newark College of Engineering, "Self-Appraisal Methods for Valuable Characteristics in Engineering"; and K. B. McEachron, General Electric Company, "Integrating the Young Engineer into His Community."

Successful systems used by industry for training young engineers in on-the-job orientation and advanced college training were described. Methods which industry might use to welcome the young engineer and his family into the company and the community were presented. In discussing examinations for registration of engineers, J. H. Foote maintained that tests that the college senior can pass but that the engineer who has practiced for five years cannot pass have not been formulated to fulfill their intended purpose.

In discussions after the papers had been presented it was brought out that the greatest desire of the young engineers is for security, while the older engineers feel that young engineers should be more concerned with service to the community, professional growth and development, and further training.

Mobile Radio Session Considers Channel Economy, Telemetering

First New York meeting under the auspices of the recently formed Radio Communications Systems Committee considered rockets, railroads, and maximum channel utilization under the general heading, "Mobile Radio." G. T. Royden, Chairman of the committee, which was a subcommittee of the old Communication Committee until last August, presided at the technical session, held in the Statler Hotel's Keystone Room, Wednesday morning, February 1.

The intricacies of adjacent channel operation were reviewed in the morning's first paper, "Design of Communication Equipment for Maximum Channel Utilization." The author, L. P. Morris of the Galvin Manufacturing Company, Chicago, Ill., was complimented by several of those present for having presented one of the first comprehensive reviews of the subject. It was recommended that this paper be considered for future publication.

Mobile radio as applied to railroads was discussed in the next presentation, "Frequency Assignment for Railroad Radio Service." Here, L. E. Kearney of the Association of American Railroads described Federal Communication Commission frequency allocations. At present, railroads are operating on 41 frequencies in the Chicago area and 39 throughout the remainder of the country.

The author being unable to attend, his colleague at the Naval Research Laboratory, Nolan R. Best, delivered J. T. Mengel's paper, "Pulse Time Modulation Telemetering Systems for Rocket Application." Two telemetering systems for use in high-altitude rockets were described. In the first of these, called the sequential pulse system, the duration of time between pulses is employed as the data code. The other scheme, called the matrix system, makes use of the position of the pulse in the time interval.

Control Techniques Feature Electric Welding Session

Controls was the theme of the afternoon session on Electric Welding, held in Parlor 2 of the Hotel Statler, Wednesday, February 1. Chairman of the meeting, at which three conference papers were presented, was J. W. Gore, Bethlehem Steel Company, Baltimore, Md.

As a hand-welding machine may be idle as much as 80 per cent of the working day, considerable power is wasted if the equipment is energized continuously. On the production line, however, shutting off power to the welder is a time-consuming procedure, but automatic start-stop controls will de-energize the machine when necessary, thus eliminating kilowatt wastage. This was the thesis of F. H. Varney of the D-V Welding Controls Company, in his paper, "Power Saving Controls." He stated that with stop-start controls savings may range from 5 to 12 dollars per machine per month in expensive power areas, and that in regions where hydroelectric power is used, operating cost is lowered by five dollars per machine per year.

The theory behind "Submerged Arc Welding Control" was described by E. A. Smith of the Lincoln Electric Company, Cleveland, Ohio. Coauthor of the paper, which was complimented by Mr. Gore as an interesting presentation, was Mr. Smith's colleague at the company, L. K. Stringham.

"Unionmelt Automatic Welding Control" was discussed by J. A. Kratz of The Linde Air Products Company, New York, N. Y.

Television-Tower Talk Highlights Broadcasting Facilities Session

Engineers of the opinion that all of television's technical problems lie in tube and circuit design had their perspective consider-

ably enlarged by Charles Singer of station *WOR-TV* at the technical session on Broadcasting Facilities, held in the Keystone Room of the Hotel Statler, on the morning of February 2, W. L. Lawrence presiding. In a talk on "*WOR-TV* Television Station Construction Problems," Mr. Singer told of the many obstacles that had to be overcome in the erection of the television station's transmission tower and in the acquisition of broadcasting studios.

No end of safety precautions were required of the construction workers when the tower was built, as it was situated right in the middle of a heavily populated residential-business area on a small plot of ground only $1^1/_2$ acres in size. Located in North Bergen, N. J., $2^1/_2$ miles from Times Square, the antenna extends 1,050 feet above sea level. The tower construction was finished in 107 days, and it took 50 days to affix the huge identification letters, *WOR-TV*, to the tower.

Television tubes and circuits also had their innings at the session. L. F. Diese and L. W. Gregory of the Westinghouse Electric Corporation expounded on "A 5-Kw Iron Core Coupled Radio Transmitter." In "The Application of Germanium Diodes in High- and Ultrahigh-Frequency Television Receivers," J. H. Sweeney of the General Electric Company related how these diodes are now being used to replace such elements as *6H6* and *6AL5* tubes, copper-oxide, selenium, and silicon rectifiers. In television receivers, his company's type *1N64* diode may be employed as a second detector, and the type *1N65* diode as a d-c restorer. Physical ruggedness, small size, no hum, and self-healing properties characterize germanium diodes. In response to a question from Harold Goldsmith of the General Ceramics and Steatite Corporation, Keasbey, N. J., on life expectancy, Mr. Sweeney stated that he had observed a 0.4 per cent replacement rate in six months on germanium diodes generally.

Higher brightness, improved pictures, and better focus in television sets was claimed by C. E. Torsch of the General Electric Company for his new "Universal-Application Cathode-Ray Sweep Transformer with Ceramic Iron Core."

High-Frequency Measurements in Television Described at Session

Equipment devised by the Philco Corporation for testing television receivers was described in the first two papers heard at the session on High-Frequency Measurements, held in the Hotel Statler's Georgian Room, Thursday afternoon, February 2, E. P. Felch presiding. Joseph Fisher presented the "Television Transient Analyzer," apparatus which can be used to compare picture detail and transient response. The transient analyzer, consisting of a 150-volt power supply, square-wave clipper, modulator, and marker generator, is designed to operate in conjunction with three pieces of commercial test equipment: a radio-frequency signal generator, a square-wave generator, and an oscilloscope. Rendition of picture detail is judged by response of the receiver to the application of a 100-kc square wave.

In the second Philco paper, Jack Fogarty discussed a "Television Impulse Interference Generator." The equipment generates controllable impulse noise, simulating the action of ignition and other short-duration noise on television sets. It enables comparative tests to be made of the effects of varying amounts of noise on different types of synchronizing circuits.

Measuring dielectric constants, studying thin surface layers, making comparative measurements of surface resistivity, testing shot blasts—these are some of the tasks that may be performed by the versatile apparatus described by S. C. Clark of the General Electric Company. Bringing along a 3,000-megacycle model for examination by his audience, Mr. Clark spoke on "Unusual Applications for a Resonant Cavity Dielectric Measuring Equipment."

Use of direct-reading film scales, thereby shifting the drudgery from the user of the instrument to the operator who calibrates the apparatus, is how W. J. Means and T. Slonczewski of the Bell Telephone Laboratories have attacked the problem of "Automatic Calibration of Oscillator Scales." Mr. Means, who delivered the paper, distributed film samples to his hearers.

R. W. Beatty of the National Bureau of Standards outlined the mathematical steps to be followed in "Determination of Attenuation From Impedance Measurements." Resolving attenuation into two components, dissipative and reflective, Mr. Beatty stated that the radius of the reflective-coefficient circle described the efficiency of the attenuator. The reflective coefficient decreases with increasing decibel rating of the attenuator, and beyond 20 decibels the coefficient is negligible.

In the last paper of the afternoon, "Progress and Development of Crystal Unit Test Oscillators," L. F. Koerner of the Bell Telephone Laboratories reviewed the history of crystal units, and stated that in the near future, his company would be putting out data sheets detailing the characteristics of present-day units.

Four Conference Papers Consider Electron Tubes

Four conference papers were presented at the session on February 2 where electron tubes in general were considered. The chairman of this session was J. T. Thwaites, Westinghouse Electric Corporation.

"Microphonism Investigation" was the subject of the opening paper, presented by L. Feinstein, Sylvania Electric Products, Inc. Test apparatus was described which mechanically vibrated the vacuum tube at frequencies up to 10 kc and tube elements experiencing excessive vibration were detected by means of a stroboscopic light source. The electrical effects were indicated on a vacuum-tube voltmeter, an oscilloscope, and a sonic analyzer in the tube's output circuit. This investigation is intended to supply information concerning the mounting of tube elements during manufacture.

"The Use of Conductance Curves for Pentode Circuit Designs" was read by K. A. Pullen and written with A. H. Hodge, both of Aberdeen Proving Ground. These curves should prove valuable to tube designers and also to students. E. K. Smith, Electrons, Inc., presented a paper entitled "Arc Drop of Hot-Cathode Gas Tubes in Service—Measurements Methods and Data." This concerned one of tube user's greatest problems: when is a tube nearing the end of its useful life and so should be replaced? Methods for determining such data while a tube is operating were described.

A new development in multielement gas-filled tubes was described by M. A. Townsend, Bell Telephone Laboratories, Inc., in "A Cold Cathode Counting or Stepping Tube." This glow-discharge multicathode single-anode tube, although still in the laboratory stage, will likely be found to be most useful in digital counters.

Transmission and Distribution Problems Are Studied

Various problems concerning engineers in the transmission and distribution field were studied in a Thursday, February 2, session presided over by I. W. Gross of the American Gas and Electric Service Corporation. The expression of transmission losses in terms of source loading was covered in "Total and Incremental Losses in Power Transmission Networks," by J. B. Ward, J. R. Eaton, and H. W. Hale of Purdue University. Formulas for a 4-source system were given and ways of solving them using the superposition method were presented.

Test techniques and fundamental theory used in obtaining "Dielectric-Recovery Characteristics of Power Arcs in Large Air Gaps," as well as the data obtained from their use, were presented by G. D. McCann, J. E. Conner, and H. M. Ellis, all of the California Institute of Technology.

A unique instrument for determining the voltage gradient at the earth's surface was described by R. L. Tramaine and R. C. Cheek of the Westinghouse Electric Corporation. The meter has a continuously-rotating plate (rotor) which alternately shields and exposes the detector plates (stator) to the earth's electric field. The current thus obtained is grounded through a large resistor, and the voltage across this resistor is amplified to actuate an indicating meter and a graphic meter. This portable meter has been made insensitive to 60-cycle a-c fields by use of a synchronous rotor speed of 900 rpm. It operates from a 110-volt a-c power source and indicates the polarity of the field as well as its magnitude.

Facsimile Session Covers Radio and Wire Transmission

The conference papers presented at the session on Facsimile held on February 2, of which W. G. H. Finch, Finch Telecommunications, Inc., New York, N. Y., was chairman, covered the transmission and reception of pictorial intelligence by radio and by wire.

The session was opened with an address by Captain A. L. Becker, United States Navy, the Assistant Chief of the Bureau of Ships. He reviewed the extent to which facsimile had been used in World War II: how it had facilitated the repair of ships by sending the latest working drawings to the yard where a damaged vessel had been brought; how weather maps were broadcast to ships at sea; how reliable reconnaissance information was transmitted quickly to points where it was of greatest value, and so forth. The Bureau of Ships is now responsible for facsimile development in the Navy, and

Captain Becker requested his listeners to cooperate with the Bureau in keeping it up to date with future developments in this field.

John V. L. Hogan, Hogan Laboratories, traced the history of facsimile from its earliest conception in the last century to the present-day state of the art. He said that its future depended upon the decision of the Federal Communications Commission as to whether facsimile broadcasting would be permitted by frequency modulation on the higher frequencies.

The methods of transmitting news photographs over telephone lines were described by R. Chapman, of Acme Wire Photos. This method of distribution, now approximately 500 photographs weekly, has practically reduced the mailing of pictures to zero. He was followed by R. Hammond, RCA Communications, Inc., who described the interconnecting international facsimile circuits with those of the three photograph agencies in the United States. The main problem encountered is the dissimilar speeds and phasing employed here and abroad; it is hoped that some degree of standardization can be achieved at the international meeting to be held in Prague in 1951.

An 1,800-cycle synchronous motor was described by A. G. Cooley, Times Facsimile Corporation, and the telegraph office Desk-Fax concentrator, which is now operating in nine cities, was discussed by A. W. Breyfogel, Western Union Telegraph Company. The Desk-Fax transmitter was described by J. H. Hackenberg and the receiver by F. G. Hallden of the same company. An electrosensitive paper for use in facsimile apparatus was described by M. Alden of the Alden Products Company, and the session was concluded by the paper entitled "Electronic Flat Scanning Facsimile Applications," by W. G. H. Finch and C. R. Jones of Finch Telecommunications, Inc. Mr. Finch described a newly developed high-speed scanning system for the transmission of intelligence on file cards which is essentially automatic, as the cards are stacked flat in a hopper by hand and fed singly through the scanning mechanism automatically, from which the information on the cards is put on the air. The receivers are of conventional design with an automatic phasing system.

General Industry Applications Attracts Sizable Audience

J. C. Fink of the Westinghouse Electric Corporation, East Pittsburgh, Pa., presided over a session on General Industry Applications which attracted a large and interested audience to the Hotel Statler's Georgian Room on Thursday morning, February 2, of the Winter General Meeting.

The use of electric power, equipment, and wiring systems is indispensable in hazardous locations, and it is the problem of the electrical engineer to use precautionary measures that will prevent explosion and fires from electrical causes, such as arcing, sparking, and overheating. In a paper entitled, "Explosion Hazards in Industry and Their Relation to Electrical Installations," Kennard Pinder of E. I. du Pont de Nemours and Company, Inc., Wilmington, Del., attempted to provide information that will assist plant management and engineers in determining the factors necessary for electrical installations in various types of hazardous areas; to show that approved electric equipment and its installation according to National Electrical Code requirements is necessary for the protection of life and property and to help in recognizing the limitations of electrical installations in hazardous areas; and to point out that once an installation is made in a hazardous area, it must be maintained in a satisfactory manner if it is to function safely and properly.

The discussion was continued by A. F. Matson of the Underwriters' Laboratories, Chicago, Ill., who outlined the "Underwriters' Laboratories' Classification and Test of Electric Equipment for Hazardous Locations," while the subject of "Motor Selection for Hazardous Locations" was covered by J. Z. Linsenmeyer of the Westinghouse Electric Corporation, East Pittsburgh, Pa., who described the various types of motors that are available and illustrated some of the applications that have been made. R. P. Northrup, Crouse-Hinds Company, Syracuse, N. Y., in a paper by Mr. Northrup and C. H. Bissell of the same company, discussed "Wiring Equipment Methods for Hazardous Locations." To conserve time, his discussion was limited to equipment in Class *1* hazardous areas—those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

A highlight of the session was a demonstration by Dr. F. W. Atkinson of the Takk Corporation, Newark, Ohio, of static eliminator bars designed for installations such as offset presses to obtain complete neutralization of static charged material, and of equipment developed in collaboration with the United States Bureau of Mines which, by purposely creating a spark, checks whether the particular vapors present will explode.

Technical paper 50-9, "Basic Patterns for Arrangement of Electric Power Systems for Steel Mills," by H. J. Finison, Armour Research Foundation, was presented by title only.

Artificial Respiration Main Topic of Session on Safety Activities

"Latest Developments in the Field of Resuscitation" provided the main subject for a highly interesting session on Safety Activities of the AIEE, presided over by Dr. W. B. Kouwenhoven, Johns Hopkins University, Baltimore, Md., on Thursday afternoon, February 2, of the AIEE Winter General Meeting.

In discussing the various methods of resuscitation under the general title, "Artificial Respiration," Dr. H. L. Motley of the Jefferson Medical College Hospital emphasized the importance of beginning a manual method of resuscitation within five minutes after breathing completely stops and while awaiting other aids such as inhalators. Oftentimes, as a matter of fact, the manual method will prove sufficient, although where there is a loss of muscle tone a respirator must be applied also as soon as it can be obtained. In the matter of such supplementary aids, the use of oxygen rather than carbon dioxide was strongly recommended, inasmuch as the victim already has too much of the latter. Dr. Motley also described a solution to the problem of giving artificial respiration in airplanes where space is limited. Here a bellows has been developed with an automatic cyclic valve which provides spasmodic pressure. Dr. C. K. Drinker of Harvard University questioned Dr. Motley as to the value of suction for expiration (negative pressure) and the latter agreed that enough ventilation is obtained through intermittent positive pressure.

Acting on the assumption that, if one could cause the diaphragm to stimulate the motion of breathing, one could thus stimulate the lungs, Dr. J. L. Whittenberger of the Harvard School of Public Health, in conjunction with Dr. David Sarnoff and others, has developed an apparatus which accomplishes this through galvanic stimulation of the phrenic nerve. This equipment, as described by Dr. Whittenberger in his paper, "Electrophrenic Technique," applies electric impulses to the phrenic nerve in a smooth voltage curve which is decreased in the same way to relax the diaphragm. One of the most important uses for the electrophrenic technique has been in cases of bulbospinal poliomyelitis (where polio has attacked the phrenic nerve) and a colored motion picture was shown illustrating the first treatment of a bulbar-polio patient with this equipment. Dr. Whittenberger's paper excited many questions and comments as to the development and applications of the electrophrenic method of resuscitation.

In the final conference paper of the session, Dr. Drinker considered "Resuscitation Problems," pointing out that there has been no substantial improvements in manual methods since the prone pressure method. One current problem is the development of a respirator which would leave the legs free and thus contribute greatly to the comfort of the patient who is confined to a respirator almost continually.

Included also in this session were brief summaries of the following technical papers which were presented in full last year: 50-2, "Electric Fences," C. F. Dalziel, University of California; 50-104, "Electrical Hazards to Farm Stock Prepared for Safety Committee of the AIEE," W. B. Buchanan, The Hydro-Electric Power Commission of Ontario; 50-105, "Protective Grounding of Electrical Installations on Customer's Premises," A. H. Schirmer, Bell Telephone Laboratories, Inc.; 50-106, "Rural Neutral Potentials," J. H. Waghorne, The Hydro-Electric Power Commission of Ontario.

Three Papers Highlight Session on Instruments and Measurements

In a session on Instruments and Measurements on Thursday, February 2, with W. R. Clark presiding, considerable interest centered about three papers: "Three-Phase Measurements of Resistance," "Power Measurement by the Hook-on Method," and "Impulse Measurements by Repeated-Structure Networks," which was presented by Professor C. L. Dawes.

The paper on "Power Measurement by the Hook-on Method," presented by A. L. Nylander of the General Electric Company, contained the development which makes possible the measurement of power by the same convenient means as the hook-on method heretofore provided for the measurement of current. Professor Dawes explained

that the investigation of the use of repeated-structure networks for impulse measurements was suggested by P. L. Bellaschi and his subcommittee and that the networks have a very good frequency response with faithful transmission. The work may prove valuable for those who have to do with this type of measurement in high-voltage laboratories.

Dielectrics Provide Subject for Two Friday Symposia

To better acquaint electrical engineers with the properties of dielectrics from a physicist's point of view, two symposia with fundamental, educational types of papers were cosponsored by the American Physical Society and the Subcommittee of the Basic Sciences Committee on Electrical Properties of Solids and Liquids on Friday, February 3, with J. A. Becker presiding.

In opening the symposium, Dr. Becker paid tribute to Professor A. von Hippel, who presented the first paper, for the excellence of the program and the arrangements. In introducing the subject Professor von Hippel outlined the objectives and approached the subject from the point of view of Maxwell's classical theory and three parameters or tables: magnetic permeability, electrical permeability, and conductivity. He explained that dielectrics should be looked upon not only as a material, but from the point of view of treating matter, and that there was a need to train engineers not only in field concepts and circuit concepts, but in dielectric concepts. Subsequently, papers were presented by well-known authorities on the "Structure and Polarization of Atoms and Molecules," "Relaxation Phenomena in Liquids and Solids," and "Modern Plastics." In the afternoon session, papers were presented on "Conduction Phenomena in Gases," "Conduction in Liquids and Plastics," and "Fluorescence and Phosphorescence."

Electronic Instruments Discussed at Session on Friday Morning

New electronic instruments was the subject of the session on the closing day of the Winter General Meeting, February 3. W. H. Tidd, Bell Telephone Laboratories, presided over the session.

The opening paper was presented by C. R. Ammerman of Pennsylvania State College on "The Direct Measurement of Bandwidth," which appears elsewhere in this issue (*pp 207–12*). M. L. Kuder of the National Bureau of Standards described and demonstrated his electron tube characteristic generator, whereby a family of plate voltage-plate current characteristics for a pentode or triode were set up on the cathode-ray tube oscilloscope in the output of the circuit. Other characteristics of other types of tubes can be established similarly with various voltages impressed on the elements.

D. W. Craig of Reed Research, Inc., read R. D. Campbell's paper, "Thermal Feedback Circuit for Computation and RMS Measurement." This is the "Diotron" circuit by means of which two voltages can be multiplied together or divided, one voltage can be integrated with respect to a second, one voltage can be differentiated with respect to another, and so forth. "A New Cathode-Ray Oscilloscope for Impulse Testing," by W. G. Fockler was described and demonstrated after the session, which was closed with a paper, "The Metrotype System of Digital Recording and Telemetering," by G. E. Foster, Metrotype Corporation. This system enables as many as 40 readings to be made at remote points and recorded at a central point on a paper strip by teletype apparatus.

Protective Devices Session Presents New Developm

A session designed to cover new developments in protective devices was presided over by H. R. Stewart of the New England Power Service Company on February 3. It was opened by the presentation of a new Lightning Arrester Standard which has been approved by the Protective Devices Committee and the AIEE Standards Committee and has now been submitted to the American Standards Association as a revision to their Standard *C62*. The new Standard combines AIEE Standards *24*, *28*, and *47*, as well as giving a table of insulation withstand tests and ratings for grounded-neutral lightning arresters.

At the same session, T. J. Bliss, Westinghouse Electric Corporation, presented a paper by himself and R. L. Witzke, Westinghouse Electric Corporation, on "Surge Protection of Cable-Connected Equipment." In addition to presenting data concerning the behavior of power cables subjected to surge currents with a 10,000-ampere crest, this paper demonstrated the ability of the analogue computer to handle problems in the determination of this behavior. The third paper in this group was a report by the Fault-Limiting Devices Subcommittee of the AIEE Committee on Protective Devices.

Cable Insulation Discussion Featured at Friday Session

F. R. Benedict, Westinghouse Electric Corporation, East Pittsburgh, Pa., presided at a session on Friday afternoon, February 3, on the subject of Chemical, Electrochemical, and Electrothermal Applications.

Very well received by representatives of cable manufacturers at this session were two papers by F. S. Glaza of the Dow Chemical Company and J. H. McCullough of Union Carbide and Carbon Corporation outlining features of cable insulation necessary for chemical plants. These papers discussed insulation breakdown and failures in joints, switchboards, and control panels; described typical installations; and made recommendation for ways in which cable manufacturers could improve equipment for this use to help the operating engineers of chemical plants with some still-unsolved problems.

Radiant Heating and Heat Pump Featured at Applications Session

The heat pump and radiant heating were considered at a well-attended technical session on Domestic and Commercial Applications, held Friday morning, February 3, in Parlor 2 of the Hotel Statler, C. F. Scott, presiding.

Well water provided the optimum source and sink, C. H. Coogan of the University of Connecticut related in presenting his paper, "A Critical Examination of Heat Sources and Sinks for Heat Pumps."

Since well water is unavailable in the Tennessee Valley Authority region, it was necessary to have recourse to the earth as a possible heat source, G. H. Hickox of the University of Tennessee stated. Speaking on "Some Practical Aspects of the Use of the Earth as a Heat Source," Mr. Hickox reported on studies made of soil moisture content, temperature, diffusivity, and conductivity made at various sites in the TVA area.

Design problems that must be solved in order to put the heat pump in the range of the average pocketbook were outlined by T. C. Johnson of the General Electric Company in his paper, "Heat Pump Design." More engineering work on the air-to-air heat pump is required. The incorporating of a motor-compressor into the heat-pump's refrigerant circuit needs more study. In conclusion, Mr. Johnson called upon electrical engineers to develop an inexpensive variable-speed a-c motor, the existence of which, he stated, would aid him immeasurably in his aim of getting the heat pump on the mass market.

According to R. C. Cassidy of the United States Rubber Company, there exists an intense consumer interest in "Radiant Panel Heating." He described the type of panel manufactured by his company, which consists of a block of conductive rubber rimmed on two opposite edges by tapelike metal electrodes. Studies indicate that from the standpoint of human comfort and physical laws these are best located in the ceiling.

An apparently anomalous but easily explainable feature of radiant panel heating, Mr. Cassidy stated, is that as the outdoor temperature drops, the owner of the heating system will feel too hot, and will push down the thermostat. Reason is that an increased temperature differential between outdoors and indoors will step up the demand on the panels, thereby making the surfaces of the room hotter.

Radiant heating is accomplished with warm surfaces, and not with warm air, as in convection heating. Persons in a radiant-heated room will be comfortable when the air temperature is 65 degrees Fahrenheit.

Another type of radiant-heating equipment in the form of cable was described by L. N. Roberson of Seattle, Wash. Speaking on "Radiant Electric Heating," he showed slides of various commercial and residential buildings which used the heating cable put out by his company. He stated that based on the one cent per kilowatt rate in the Seattle area, operation costs are comparable with oil at ten cents per gallon.

Institute Prizes Awarded for 1948–49 Technical Papers

The winners of the 1948–49 Institute prize awards for technical papers have been announced by Professor C. H. Willis, Chairman of the Committee on Award of Institute Prizes, and also Chairman of the AIEE Technical Program Committee. Each Institute first prize award consists of $100 in cash and an appropriately embossed certifi-

cate, the cash award being divided where there are two or more coauthors. Second prize winners have been awarded an embossed certificate.

Communication Group. First prize awarded to Eric A. Walker (A'34, F'47) of the Pittsburgh Section (The Pennsylvania State College) for his paper entitled, "An Electro-Acoustical Locating System," which was presented originally at the 1948 Winter General Meeting in Pittsburgh, Pa. Second prize was awarded to E. S. Willis (A'45, M'48) of the New York Section (Bell Telephone Laboratories, Inc.), for his paper entitled, "Crystal Filters Using Ethylene Diamine Tartrate in Place of Quartz," which was presented originally at the 1948 Winter General Meeting in Pittsburgh.

General Applications Group. First prize awarded to L. W. Birch (A'20, M'29) of the Mansfield Section (Ohio Brass Company) for his paper entitled, "Are the Overhead Distribution Costs Retarding Railroad Electrification?," which was presented originally at the 1948 Winter General Meeting in Pittsburgh. No second prize was awarded in this group.

Industry Group. First prize awarded to H. Chestnut (A'41, M'48) and R. W. Mayer (nonmember) of the Schenectady Section (General Electric Company) for their paper entitled, "Comparison of Steady-State and Transient Performance of Servomechanisms," which was presented originally at the 1949 Summer General Meeting in Swampscott, Mass. Second prize was awarded to A. C. Hall (M'44) of the Boston Section (Massachusetts Institute of Technology) for his paper entitled, "Damper Stabilized Instrument Servomechanisms," which was presented originally at the 1949 Winter General Meeting in New York, N. Y.

Power Group. First prize awarded to R. L. Witzke (A'37, M'45) of the Pittsburgh Section (Westinghouse Electric Corporation) for his paper entitled, "Voltage Recovery Characteristics of Distribution Systems," which was presented originally at the 1949 Winter General Meeting in New York. In this group two papers were awarded second prize, T. E. Browne, Jr. (A'36, M'45) of the Pittsburgh Section (Westinghouse Electric Corporation) for his paper entitled, "A Study of A-C Arc Behavior Near Current Zero by Means of Mathematical Models," which was presented originally at the 1948 Winter General Meeting in Pittsburgh, Pa.; and L. F. Hickernell (A'25, F'34), A. A. Jones (M'46), of the New York Section (Anaconda Wire and Cable Company), and C. J. Snyder (A'37) of the St. Louis Section (Westinghouse Electric Corporation) for their paper entitled, "Hy-Therm Copper—An Improved Overhead-Line Conductor" which was presented originally at the 1949 Winter General Meeting in New York.

Science and Electronics Group. First prize awarded to W. N. Lundahl (A'48) of the Maryland Section (Westinghouse Electric Corporation) for his paper entitled, "X-Ray Thickness Gauge for Cold Rolled Strip Steel," which was presented originally at the 1948 Winter General Meeting in Pittsburgh. Second prize was awarded to A. H. Waynick (A'45, M'49), Eric A. Walker (A'34, F'47), and Peter G. Sulzer (nonmember), for their paper entitled, "Polar Vector Indicator" which was presented originally at the 1949 Winter General Meeting in New York.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Group

Project Group on ASA-C *37.2-1945* of the Committee on Substations. Several years ago quite an interesting and active discussion of the difficulties attendant to the using of "device function numbers," as now standardized in the foregoing Standard, took place. As a result of this discussion, an intense study of the matter has been made, and a preliminary report was prepared and submitted to the main committee. After some review and discussion it was decided to appoint a working group to prepare a questionnaire and circulate it among the interested members of the industry. This working group consisted of R. C. Ericson (Chairman), H. Bany, L. B. LeVesconte, M. E. Reagan, and M. S. Schneider. An approved questionnaire was circulated and the returns analyzed. The replies indicated that the industry is not exactly satisfied with the present system, but is against any radical change. The next move probably will be to revise the present Standard somewhat and bring it up to date.

Science and Electronics Group

Committee on Nucleonics. (*J. J. Smith, Chairman; W. F. Davidson, Vice-Chairman; P. N. Ross, Secretary.*) A second joint conference under the auspices of the AIEE and the Institute of Radio Engineers on Electronic Instrumentation in Nucleonics and Medicine was held at the Hotel Commodore in New York, N. Y., October 31–November 2, 1949. The AIEE committees participating were the Nucleonics Committee and its Subcommittee on Nucleonic Instruments and Measurements and also the Electronics Committee and its Subcommittee on Electronic Aids to Medicine. The conference was attended by more than 800 persons and considerable interest was shown. It is planned that the papers presented there will be published jointly by the two Institutes. Plans are already under way for a similar joint conference on the same subject next fall.

The committee is continuing participation with the National Research Council toward the preparation of a glossary of nuclear terms.

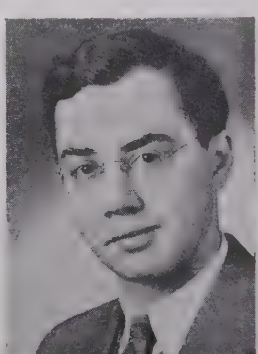
A conference at the recent Winter General Meeting in New York was sponsored by the Joint Subcommittee on Nucleonic Instruments at which five papers were presented. Also, meetings of the Nucleonics Committee and some of its subcommittees were held during the Winter Meeting.

AIEE PERSONALITIES.....

R. V. L. Hartley (A '16, M '23), Research Consultant with the Bell Telephone Laboratories, New York, N. Y., and originator of the famed Hartley oscillator circuit, has retired. Born in Spruce, Nev., November 30, 1888, he was graduated from the University of Utah. After completing three years of study under a Rhodes Scholarship at Oxford University, he joined the American Telephone and Telegraph Company, New York, N. Y., in 1913. He developed his oscillator circuit soon afterward. During World War I, while working on the problem of binaural location of a sound source, he formulated the now accepted theory that direction is perceived by the phase difference of sound waves due to the longer path to one ear than the other. At the war's end, Mr. Hartley took over research into repeaters, voice- and carrier-transmission. He made many contributions to power and communications theory. He fostered the treatment of telegraph pulses by Fourier analysis so that a-c measurements could be made in telegraph transmission studies. In an attempt to secure some measure of privacy for radio, he developed the simple frequency-inversion system known to the initiated as "greyqui hoy." In a paper presented before an international conference at Lake Como, Italy, in 1927, he enunciated his well-known law that "the total amount of information which may be transmitted over a system is proportional to the product of the frequency range which it transmits and the


R. V. L. Hartley


R. C. Cheek


L. G. Gitzendanner

time during which it is available for transmission." Two years later, failing health halted Mr. Hartley's work for several years. In 1939, he returned to Bell Laboratories to become a Research Consultant on transmission problems. Mr. Hartley is a fellow of the Institute of Radio Engineers, the American Association for the Advancement of Science, and the Physical and Acoustical Societies. The Institute of Radio Engineers Medal of Honor was awarded him in 1946. Seventy-two patents and five papers record his contributions and developments.

Robert Chase Cheek (A '42, M '47), Central Station Engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., is winner of Eta Kappa Nu's outstanding young electrical engineer award for 1949 (*EE, Feb '50, p 178*). Born November 14, 1917, in Charleston, S. C., Mr. Cheek was graduated from the Georgia Institute of Technology in 1941. Subsequently, he enrolled in the graduate student course of the Westinghouse Electric Corporation, serving as Chairman of the graduate student group until he completed the course. He became permanently located in the Central Station Engineering Section in January 1942. Less than two years later, he received his Master of Science degree under the University of Pittsburgh–Westinghouse study plan. Since 1945, Mr. Cheek has been the Headquarters Central Station Engineer assigned to the Southeastern District. Analytical studies which he has made on the comparison of modulation systems for powerline carrier transmission are now used as a standard reference work in the carrier field. Author of 16 technical articles published in such magazines as *Electrical World*, *Electric Light and Power*, and the *Westinghouse Engineer*, he has presented nine technical papers before AIEE and other engineering societies. Mr. Cheek has worked on the problem of grounding large power stations. He has invented an electronic multiplier, devised a method of predicting safe loadings of power transformers, and has contributed to the development of microwave communication equipment. Inventor of an automatic volume-control system for radio receivers, he has published a method for calculating the impedance characteristics of power cables.

Louis George Gitzendanner (A '42, M '49), who won honorable mention in Eta Kappa Nu's outstanding young electrical engineer competition, is a Section Engineer in the General Electric Company's General Engineering and Consulting Laboratory at Schenectady, N. Y. (*EE, Feb '50, p 178*). Born March 27, 1919, in Queens County, New York, N. Y., he attended Lehigh University, receiving his Bachelor of Science degree in electrical engineering in 1941. Starting as a Test Engineer with General Electric, he was assigned to the General Engineering and Consulting Laboratory in January 1942. Here, his work was largely for the Armed Forces, dealing with fluxmeters, magnetometers, optical instruments, underwater sound, vibration, and heat transfer. As a result of work on the Mark VI magnetic mine-sweeping controller, he received the company's Charles A. Coffin award. Mr. Gitzendanner, in his present post in the Design Section of the Electro-Mechanical Division, directs the activities of over 40 engineers and technical assistants in the development of equipment for use in nucleonics, radar, and underwater sound work. Three patents have been issued in his name and dockets for 12 additional patents have been filed. In 1945, he aided in reorganization of the Schenectady General Electric Engineers Association and is Secretary of the Professional Developments Committee of that organization. From 1946 to 1949, he served as a co-ordinator of group study for New York Professional Engineering Licenses, obtaining his own in 1947. He is now registered as a professional engineer in New York State and is a member of the National Society of Professional Engineers.

Dayton Ulrey (A '34), Chief Engineer, Tube Department, Radio Corporation of America, Lancaster, Pa., has retired and been retained as a Consultant by the company. An early researcher into vacuum tube design, Dr. Ulrey's contributions include the development of processes for creating vacuum-tight metal-to-glass seals, the principle used in metal-coned television picture tubes. He was also responsible for important studies in the production of high vacuum, particularly the absorption and evolution of gases by glass and metals, vital to the operation of all electron tubes. Dr. Ulrey joined RCA in 1937 as Manager of power-tube development, and in 1942 was selected to organize the engineering personnel and facilities for the Lancaster plant, which became the greatest single producer of cathode-ray tubes used in radar and other equipment by the Armed Forces. Born 65 years ago in Indiana, Dr. Ulrey graduated as a physics major from Indiana University in 1911 and received his master's degree from the same university in 1912. He was appointed instructor in physics at the University of Pittsburgh, and received his Doctor of Philosophy degree from Stanford University three years later. Returning to the University of Pittsburgh in 1917 as Assistant Professor of physics, he started his studies on the production of high vacuum and vacuum-tight metal-to-glass seals as part of a program undertaken by the Bureau of Standards. In 1918, Dr. Ulrey joined the Westinghouse Research Laboratory, and in 1923 was placed in charge of the Physics Division, with responsibility for vacuum-tube development and research. Dr. Ulrey is a member of the American Physical Society, the American Association for the Advancement of Science, and the Institute of Radio Engineers. At present, he is serving on the AIEE Electronics Committee.

I. H. Sclater (A '08, F '27, Member for Life), Consulting Engineer, Power Transformer Engineering Division, General Electric Company, Pittsfield, Mass., retired January 1. Friends and work associates honored Mr. Sclater at a party on January 10 at the White Tree Inn. A native of Richmond, Va., Mr. Sclater earned his Bachelor of Science in electrical engineering degree from Virginia Polytechnic Institute in 1905. Later that year he entered the Lynn Works in the Testing Department. He was assigned to the Distribution Transformer Engineering Department at Lynn in December 1906. When this work was transferred to Pittsfield in 1907, Mr. Sclater was given charge of constant current transformer design and held that position until August 1913 when he was transferred to Pittsfield to work again on the development of distribution transformers. In 1919 Mr. Sclater was promoted to the position of Section Head in the Distribution Transformer Section and received additional responsibilities in 1923 when the oil-filled instrument transformers were transferred from Lynn Works to Pittsfield to be assigned to him. In 1926 he was given charge of a Power Transformer Section and was responsible for the designing of small power transformers 501–3,500 kva. He was promoted to Assistant Engineer in charge of power transformers of 501–5,000 kva, high-voltage instrument transformers, and street lighting in 1931. His appointment as Division Engineer of the Power Transformer Division handling power transformers 501 kva and above, high-voltage instrument transformers, high-voltage testing transformers, reactors, and a-c arc welding transformers came in 1933. In 1938 Mr. Sclater was made Managing Engineer of the Power Transformer Division responsible for engineering, manufacturing, production, and cost of all power transformers, and in 1947 he was appointed to the post of consulting engineer in the Power Transformer Engineering Division, a position which he held until the time of his retirement. Mr. Sclater is credited with ten patents. He served as Chairman of the Pittsfield Section for one year.

R. L. Young (A '19, M '21), Power Development, Standards and Safety Department, Bell Telephone Laboratories, New York, N. Y., has retired after 39 years of service with the Bell System. Subsequent to his graduation from the University of Pennsylvania in 1907 with a Bachelor of Science degree in electrical engineering, he spent two years with the Westinghouse Electric Corporation and two years in industrial journalism. Joining the American Telephone and Telegraph Company in 1911, Mr. Young has been identified with power developments, standards and trial installation of machines, engines, batteries, filter condensers and circuits for dial switching systems, and the later unit-type power plants for toll and manual offices. Floating voltage regulating systems for storage batteries, patented by him in 1923, have since been in general use. From 1929 he has specialized in power maintenance, Bell System Practices, and the National Electrical Code. Coming to the laboratories as Power Maintenance Engineer in 1934, these specialties have been continued in the power development group. Mr. Young has been active in the American Standards Association since 1931 as alternate on the Standards Council representing the "Telephone Group." He has also held membership on several committees developing standards for storage batteries, electric measuring instruments, and symbols for drawings. He is a member of the American Society of Safety Engineers and of the National Safety Council. One of his latest projects was the preparation of design specifications for Bell System equipment for safety of personnel.

A. L. Albert (A '27, F '41), Professor of Communication Engineering, Oregon State College, Corvallis, is one of 11 AIEE members who will receive the Institute of Radio Engi-

neers Fellow Award at the forthcoming convention of that society, to be held March 6–9 in New York, N. Y. The rank of Fellow is an honorary grade bestowed by the IRE Board of Directors. The ten other AIEE men are: **Rawson Bennett** (A '38, M '45), Director, United States Navy Electronics Laboratory, San Diego, Calif.; **K. H. Blomberg** (M '43), Telefonactiebolaget L. M., Ericsson, Stockholm, Sweden; **W. G. Dow** (A '19, F '48), Professor, Electrical Engineering Department, University of Michigan, Ann Arbor; **G. L. Haller** (M '45), Dean, School of Chemistry and Physics, Pennsylvania State College, State College; **H. B. Marvin** (A '20, M '43), Project Engineer, General Electric Company, Schenectady, N. Y.; **J. H. Miller** (A '19, F '42), Vice-President and Chief Engineer, Weston Electrical Instrument Corporation, Newark, N. J.; **Simon Ramo** (A '40, M '43), Director of Guided Missile Research and Development, Hughes Aircraft Company, Culver City, Calif.; **J. R. Steen** (M '48), Director of Quality Control, Sylvania Electric Products, Inc., Flushing, N. Y.; **G. R. Town** (A '28, M '37), Professor of Electrical Engineering and Assistant Director of the Experimental Station, Iowa State College, Ames, Iowa; and **Dayton Ulrey** (A '34), Manager, Lancaster Engineering Section, Radio Corporation of America, Victor Division, Lancaster, Pa.

F. V. Magalhaes (A '07, F '19, Member for Life), Assistant to the Chairman of the Board, Consolidated Edison Company, Inc., New York, N. Y., has retired. Graduated from the Brooklyn Polytechnic Institute in 1907 with an electrical engineering degree, he was subsequently designated General Foreman in the New York Edison Company's (Consolidated Edison predecessor) Meter Department. In 1926, he became General Superintendent of distribution and installation in Manhattan. For some years he was Vice-President and Secretary of the United States National Committee of the International Electrotechnical Commission and was United States delegate to its 1922 conference in Switzerland. During World War I, he was loaned to the United States Government and he went to Nitro, W. Va., where he contributed to the early development of arc welding with alternating current. In 1928, he left New York Edison to join the Hall Heating Company, Philadelphia, Pa., and later the General Electric Company at Lynn, Mass. Returning to New York Edison in 1934, he was named Assistant to the Vice-President, and, in 1937, was chosen Assistant to the President. Although retired, Mr. Magalhaes is continuing in his post as Treasurer of the Association of Edison Illuminating Companies.

R. L. Quass (A '11, M '28, Member for Life), Systems Development Department, Bell Telephone Laboratories, New York, N. Y., has retired after 40 years of service with the Bell System. Graduated from Western Reserve University and Case Institute of Technology, at Cleveland, Mr. Quass enrolled in the student course of the Western Electric Company. Early in 1910, he was transferred to circuit work in the laboratory at New York. After World War I, during which he was engaged in Government projects, he was assigned to the adaptation of Automatic Electric Company step-by-step dial systems to meet the requirements of Bell System standards, becoming Group Supervisor. Subsequently, he was assigned to the Patent Department, later returning to step-by-step system development. Seventeen patents in all have been credited to Mr. Quass during his career in the Bell System.

F. E. Terman (A '23, F '45), Dean of the School of Engineering of Stanford University, Calif., will be awarded the 1950 Medal of Honor given by The Institute of Radio Engineers at the annual IRE convention to be held March 6 to 9, 1950, New York, N. Y. The Medal of Honor, which is the institute's highest award, is given in recognition of distinguished service, rendered through substantial and important advancement in the science and art of radio communication, by the society's Board of Directors. Educated at Stanford University, Dr. Terman became a member of the faculty as an instructor in 1925, and was advanced to Assistant Professor, Associate Professor, and full Professor and Executive Head of the Electrical Engineering Department. From 1942 until 1945 he was in charge of the Harvard University Radio Research Laboratory. Upon his return to Stanford, he was named Dean of the School of Engineering. He was awarded a decoration from the British Government in 1946, and the United States Medal for Merit in 1948. He is a past president of IRE.

L. W. Cook (A '40, M '47), Chief Engineer with the Electronic Blanket Division, Simmons Company, New York, N. Y., since 1944, has joined Starring and Company, Inc., Bridgeport, Conn., as Vice-President in charge of engineering and research. Mr. Cook was connected with the General Electric Company for ten years, starting as a Test Engineer in Schenectady in 1934. He was made Junior Design Engineer at G-E's Bridgeport plant in 1935, and in 1939 became a Senior Design Engineer. During the next five years, he was engaged in design and development work and was identified with the production of thermostatic controls for appliances and the design of fluorescent lighting fixtures.

G. W. Painter (A '47), of the Canadian General Electric Company, Toronto, Ontario, has been designated their liaison in the Montreal (Quebec) Locomotive Works diesel-electric locomotive program. He is responsible for integrating with the Montreal Locomotive Works the engineering and scheduling of Canadian General Electric's Peterborough Works, where large-scale production of the electrical components for the program is underway. Mr. Painter has been associated with Canadian General Electric since 1933.

A. L. Horelick (A '47) has been appointed Engineering Manager and **J. J. Zimsky** (A '48) has been named Chief Mechanical Engineer for the Pennsylvania Transformer Company, Pittsburgh. Mr. Horelick has been with the firm since 1938 in a number of capacities, including mechanical and electrical designing, sales engineering, and Assistant to the President. Affiliated with the organization since 1929, Mr. Zimsky's most recent post was Planning Engineer.

W. F. Taylor (M '37) has relinquished his duties as Manager of the Boston, Mass., office of the Allis-Chalmers Manufacturing Company in order to devote all his time to his post as New England Regional Manager. **J. E. Smet** (A '46), formerly representative in the company's Boston office, is now Manager of the New Haven office. **G. H. Hoffman** (A '44), Manager of Allis-Chalmers' Knoxville, Tenn., office since 1943, has been named Manager of the Birmingham, Ala., district office.

F. W. Cramer (M '40) has joined the Elliott Company as a Consulting Engineer to assist in the design, application, installation, maintenance, and sale of electric apparatus to the steel and allied industries. He will have headquarters at Pittsburgh, Pa. Prior to this assignment, Mr. Cramer had been with the Carnegie-Illinois Steel Corporation in Pittsburgh as Electrical Engineer since 1936. Formerly he had been with the Bethlehem Steel Company in Johnstown, Pa., as Assistant Electrical Superintendent and Republic Steel Company in Youngstown, Ohio, as Chief Electrical Engineer. Mr. Cramer has been very active with both the Association of Iron and Steel Engineers and AIEE. He is a Past-President of the former organization, and is now serving on the AIEE Electronic Power Converters Committee and the Mining and Metal Industry Committee.

N. L. Harvey (A '35), formerly head of the Applied Research Branch of the Physics Laboratory, Sylvania Electric Products Inc., Bayside, N. Y., has been appointed Director of Engineering of Colonial Radio Corporation, a wholly-owned subsidiary of Sylvania Electric. Mr. Harvey joined the research engineering group of Sylvania at Emporium, Pa., in the fall of 1941. During the war, he served on a variety of projects, including proximity fuses, air-borne electronic navigation instruments, and advanced types of radar equipments. Since the war, he has supervised research and development work on television circuits and electron tubes important to commercial television applications in the proposed high-frequency channels. He has also been active in the supervision of research for improvements in conventional television receiver circuits and viewing tubes. He received his Bachelor of Science degree in electrical engineering in 1934 at Iowa State College and is a senior member of the Institute of Radio Engineers.

H. H. Lowry (A '19, F '29), Assistant Director of Systems Development, Bell Telephone Laboratories, New York, N. Y., has retired after 40 years with the Bell System. He joined the Western Electric Company, Hawthorne, Ill., in 1909 after receiving a mechanical engineering degree from the University of Kentucky. He was awarded an electrical engineering degree in 1914. Named Equipment Development Engineer in 1918, he came to the Bell Laboratories in 1925. He was designated Director of Equipment Development in 1934 and Assistant Director of Systems Development in 1945. Mr. Lowry is a Senior Member of the Institute of Radio

Engineers and belongs to the New York Society of Professional Engineers.

Harvey Fletcher (M '23, F '30), until recently Director of Physical Research for the Bell Telephone Laboratories, New York, N. Y., has been appointed Visiting Professor at Columbia University in New York, teaching courses in "Elements of Acoustical Engineering" and "Speech and Hearing as Applied to Communication." Dr. Fletcher, who joined the Research Department of the Bell Laboratories in 1916, is a Past-President of the American Physical Society and has received numerous awards for his work in acoustics.

N. E. Funk (A '07, F '34, Member for Life), Executive Vice-President of the Philadelphia (Pa.) Electric Company, has been elected a corporate member of the Lehigh University Board of Trustees at Bethlehem, Pa. A 1905 alumnus of Lehigh, he has been with the Philadelphia utility since 1907. Dr. Funk is a Past-President of the AIEE (1943–44) and served as Director of the Institute, 1934–38.

Irven Travis (M '46), who is in charge of electronic research at the Burroughs Adding Machine Company, has been named to the Board of Directors of the company. Dr. Travis, formerly Supervisor of Research of the University of Pennsylvania's Moore School of Electrical Engineering, became associated with Burroughs as Director of Research in March 1949, and at that time assumed direction of the Company's new electronic research laboratory in Philadelphia, Pa. He also continued his association with the University of Pennsylvania by remaining on its faculty as a professor.

A. S. Basil (M '46) has been appointed Assistant General Sales Manager to direct national sales of the electrical wire and cable products of the Kaiser Aluminum and Cable Corporation. Formerly General Sales Manager of the United States Rubber Company's Wire and Cable Department in New York, N. Y., Mr. Basil's new headquarters are in Newark, Ohio. At the same time, **H. W. Biskeborn** (M '39), who has been a member of Kaiser's Production Department in Newark, is transferred to Electrical Cable Sales as Technical Director.

K. K. Gross (A '42), previously co-ordinating engineer, Leeds and Northrup Co., Philadelphia, Pa., has joined Specialized Instruments Corporation, Belmont, Calif., as Eastern Service Engineer for Spinco Ultracentrifuges. He will be headquartered in Philadelphia. During the war, Mr. Gross was a project engineer at Wright Field, Dayton, Ohio, working on instrumentation for aircraft rotating and jet power plants. He has also been identified with Morris Newmark and the Proctor and Schwartz Electric Company, both of Philadelphia.

R. H. Mather (A '44), formerly Manager of the Commercial and Distribution Department, The Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been named Assistant to the Vice-President and Chief Engineer. Succeeding Mr. Mather is **A. C. Abbott** (A '44) who previously was Assistant Manager of the Commercial and Distribution Department.

J. A. Hutcheson (M '44), since March 1948, Director of the Research Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been elected a Vice-President of the company. He will continue to direct the laboratories. For four years, as Associate Research Director, Mr. Hutcheson guided the formulation of the company's plans for atomic development. During the war, he headed Westinghouse's radar research program. He has been identified with the company since 1926.

M. C. Albrittain (A '43) has been appointed General Manager of the Industrial and Commercial Department of the Consolidated Gas, Electric Light, and Power Company, Baltimore, Md. With the utility 25 years, most recently he was Assistant General Manager of the department. Mr. Albrittain succeeds **R. H. Tillman** (A '08, Member for Life) who retired recently after 40 years of service.

G. N. Tidd (A '00, Member for Life) has resigned as Chairman of the Board of the American Gas and Electric Company, New York, N. Y., effective December 31, 1949. Mr. Tidd has been associated with the company since its organization in 1906, becoming President in 1923, and continued in that position until May 1947, when he became Chairman of the Board. Mr. Tidd has agreed to remain as a member of the Board and an advisor and consultant to the company. The position of Chairman of the Board is left vacant.

H. B. Bryans (M '17, F '18), President of the Philadelphia (Pa.) Electric Company, has been elected to his fifth consecutive term as President of the Electrical Association of Philadelphia. **E. W. Loomis** (A '19, M '45) District Manager, Westinghouse Electric Corporation, Philadelphia, has been designated Vice-President of the association.

R. F. E. Bunston (A '45), formerly Sales Engineer with the Burndy Company Limited, Toronto, Ontario, Canada, has been appointed Chief Sales Engineer for the firm. **A. G. Thomson** (A '44), who had been with the Canadian General Electric Company in Toronto, has become a Sales Engineer with Burndy.

J. F. Hogan (A '25), recently manager of Newell-Emmett's Industrial Department, has initiated his own consulting service on industrial and trade advertising in New York, N. Y. The service is offered to both agencies and industrial companies—the latter on a basis strictly noncompetitive with agencies. Prior to joining Newell-Emmett, Mr. Hogan was associated with the Hazard Advertising Company, New York, as house organ editor, copywriter, copy supervisor, and account executive.

T. L. Mayes (A '35, M '41) has been designated Staff Assistant to the Manager of Engineering, Small Apparatus Divisions, General Electric Company, Schenectady, N. Y. With the company since 1927, he became Works Engineer in the Oakland, Calif., works in 1947, and in 1949 returned to Schenectady on the Apparatus Design Engineering Staff.

F. E. Winslow (A '46) has been appointed Manager of the Baltimore, Md., office, Apparatus Department, Atlantic District of the General Electric Company. He succeeds **J. W. Hicklin** (A '18), who is retiring. Mr. Winslow was formerly with the Philadelphia office of the Apparatus Department.

G. A. Caldwell (A '39, M '48), previously Manager of Industrial Control engineering, Westinghouse Electric Corporation, Buffalo, N. Y., has been named Engineering Supervisor of the company's Detroit (Mich.) Engineering and Service Department. He has been with Westinghouse since 1927.

T. T. Woodson (A '33, M '47) has been appointed Engineer of the Advance Engineering Section of the General Electric Company's Appliance and Merchandise Department, Bridgeport, Conn. Mr. Woodson was formerly Designing Engineer for the Home Laundry Equipment Division. He joined the company at Schenectady, N. Y., in 1935

D. S. MacDonald (A '48) has been appointed Assistant to the Manager of the Gear Motor Sales Division of the General Electric Company's Small and Medium Motor Divisions. He was formerly a Motor Control Specialist in the firm's Apparatus Department in Baltimore, Md.

H. L. Logan (A '19, F '43) has been elected to the newly created post of Vice-President in Charge of Research for the Holophane Company, New York, N. Y. Previously, Mr. Logan was manager of the firm's Department of Applied Research. He is a member of the AIEE Board of Examiners.

H. E. Bussey (A '10, F '18, Member for Life) has retired after nearly 46 years with the General Electric Company, 41 of which have been spent in charge of engineering in the Southeastern District. He will engage in consulting work in Atlanta, Ga., and the southeast in both the mechanical and electrical fields.

F. E. Satterthwaite (A '47) has been appointed Quality Control Engineer of the Plastics Division in the Chemical Department of the General Electric Company at Pittsfield, Mass. Dr. Satterthwaite has been Quality Control Engineer for the Product Service Division of the company in Bridgeport, Conn.

R. G. Gehlsen (A '45) has been named Sales Manager, Mines Equipment Division, Joy Manufacturing Company, St. Louis, Mo. Appointed Development Engineer, Mines Equipment Division, in 1945, he was designated Manager, Mining Sales, two years later.

L. W. Caldwell (A '48), formerly in the Supply Department, Meter and Instrument Section, Canadian General Electric Company, Toronto, Ontario, Canada, has been

transferred to the firm's Calgary, Alberta, office as Sales Engineer in the company's Supply Division.

F. C. Young (A '24, F '45), formerly Vice-President in charge of research and engineering and a Director of the Stromberg-Carlson Company, Rochester, N. Y., has joined the staff of Designers For Industry, Inc., Cleveland, Ohio, as Vice-President.

J. W. Simpson (A '43, M '49) has been named Assistant Engineering Manager of the Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa. With the company since 1937, he had served most recently as Supervising Engineer on low-voltage air circuit breakers.

C. W. Jones (A '30, M '44), formerly Assistant Vice-President, has been designated Principal Officer of the Western district of Massachusetts of the New England Electric System, Boston, Mass.

W. R. Spittal (A '32) is now in charge of the Highland Engineering Company, Hicksville, N. Y., a new firm which manufactures such items as transformers, inductors, rectifiers, and power-supply equipment.

D. E. Allen (A '23) has been named Sales Manager of the Anaconda Wire and Cable Company, New York, N. Y. Mr. Allen has been associated with the firm since 1932.

C. T. Hughes (A '20, F '46), General Superintendent since 1939, has been designated Operating Vice-President, Connecticut Light and Power Company, Waterbury. Mr. Hughes has been with the utility 31 years.

E. N. Walton (A '43), formerly of H. G. Acres and Company, Niagara Falls, Ontario, Canada, has joined the staff of the Powell River Company Limited, Powell River, British Columbia, Canada.

S. K. Fosholt (A '39, M '45) has been designated Chief Engineer of the Stanley Engineering Company, Muscatine, Iowa. With the firm since 1938, Mr. Fosholt formerly was Head of the Mechanical Section.

L. O. Hoffman (A '43), has been appointed New Mexico area representative of the Automatic Control Company, St. Paul, Minn., with headquarters in Albuquerque.

J. T. Matthews (A '35), previously Assistant Manager, has been named Manager of the Foreign Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa.

R. R. Wylie (M '46) has been named Manager of the Sangamo Electric Meter Department for the Rumsey Electric Company, Philadelphia, Pa. Mr. Wylie joined the Rumsey firm in 1941.

Cecile Froehlich (M '47), formerly Assistant Professor of Electrical Engineering at the college of the City of New York has been advanced to Associate Professor.

L. V. Dugas (A '44), Power Engineer, Gulf State Utilities Company, Beaumont, Tex., has been elected President of the Petroleum Electric Power Association.

P. M. Klauber (A '42, M '49), formerly in the Engineering Department, Solar Aircraft Company, San Diego, Calif., has been named Assistant to the President of the firm.

F. A. Hutchins (A '12, Member for Life), for 43 years a member of the Motor Engineering Division, General Electric Company, Lynn, Mass., has retired.

D. T. Braymer (A '42), formerly Associate Editor, is now Managing Editor of *Electrical World*, New York, N. Y.

OBITUARY • • • • • •

James Watts Young (A '03, M '12, Member for Life), who had been active in real estate in Kingston, Pa., for many years, died February 1, 1950. Born in Washington, D. C., April 6, 1873, he was graduated from the Johns Hopkins University in 1894 with a degree in electrical engineering. From 1894 to 1899, he was employed by the American Telephone and Telegraph Company. During this time, he did engineering, construction, and maintenance work on long-distance telephone exchange equipment, principally in New York, N. Y. He also served as field representative of the New York office. In 1899, he assumed direct charge of the engineering and construction work on overhead pole lines of the Philadelphia (Pa.) Bell Telephone Company and the Delaware and Atlantic Telephone and Telegraph Company, erecting at this time about 1,000 miles of pole line. After spending one year with the New York (N. Y.) Telephone Company, he worked during 1905–06 for the Commission on Electric Lighting for the City of New York, in which post he supervised the collection and tabulation of data for reports on the design of an electric power system to supply the needs of New York's five boroughs. From 1906 to 1909, he served with the McCall Ferry Power Company, first as Assistant Engineer to the Chief Engineer and then as Vice-President. Named Assistant Chief Engineer of Light and Power, Department of Water Supply, Gas, and Electricity, City of New York, N. Y., in 1910, he had responsibility for the electrical and gas work on the city's streets and buildings. In 1917, he was designated Resident Manager of the Air Nitrates Corporation of New York at Muscle Shoals, Ala. Here, he directed the erection of a 110,000-ton ammonium nitrate plant and a 60,000-horsepower steam plant for the manufacture of ammonium nitrate for the United States Government. Coming to the Wyoming Valley in 1921, Mr. Young joined the real estate firm of Young and Loveland, later forming his own firm.

Frank Walsh (A '26, M '30), Manager of the Puget Sound Power and Light Company's Southern Division at Olympia, Wash., died January 27, 1950. Born in San Francisco, Calif., September 13, 1887, Mr. Walsh attended the University of Oregon and the University of Washington. His first experience in the electrical industry was obtained with the Portland (Oreg.) Railway, Light, and Power Company, beginning in 1908. Four years later, he became identified with the Puget Sound Power and Light Company at Bellingham, Wash. From 1917 to 1920, he served as Assistant Engineer and Assistant Superintendent. During the next three years, he was engaged in private business, returning to the Puget Sound Power and Light Company to become Superintendent of Light and Power in the utility's Eastern District. In this post, he directed engineering work on a hydroelectric station, a distribution system in Wenatchee, Wash., a steam plant, also in Wenatchee, and various substations. From 1926 to 1929, he was Superintendent of Light and Power for the company's Northeastern District. In the latter year, he became Manager of the Northeastern District, being located in Everett, Wash. Subsequently named Northwest Division Manager at Bellingham, Wash., Mr. Walsh was transferred to the managership of the Central Division of the company with headquarters at Seattle, Wash. in 1941. Six years later, he was relieved of these duties to become Manager of the utility's Southern Division. Prominent in many civic and professional activities, Mr. Walsh was a member of the Northwest Electric Light and Power Association and the Electric Club of Seattle. He had been elected to serve as Vice-President of the former society in 1937 and in 1939.

John J. Ryan (M '23) of Yonkers, N. Y., a retired electrical engineer formerly associated with the Consolidated Edison Company of New York, Inc., died on January 29, 1950. Born in New York, N. Y., on June 8, 1881, Mr. Ryan was graduated from Columbia University in 1909 with an electrical engineering degree. His association with the Edison System commenced in 1896 when he was employed in the now outmoded position of lamp boy which involved his changing the lamps on the premises of the company's customers. During the summers of 1906–08, while still attending Columbia, he was employed as a draftsman in charge of a survey of pole lines in what was known as the Bronx District of the New York Edison Company. Upon graduation, he was put in charge of the Extension and Estimating Department where he remained until 1910 when he was made Assistant General Foreman in the Bronx District. Thereafter he was made Assistant Operating Superintendent in 1912, Assistant Superintendent in 1915, Head Draftsman in 1920, and Superintendent in 1922. Mr. Ryan was elected President of the Edison Savings and Loan Association in 1943, a group which he had served as Director since 1927 and as Vice-President since 1937. He retired from this position three years ago. Mr. Ryan was permanent president of the Columbia Engineering Class of 1909, a former trustee of the Yonkers Board of Education and St. Joseph Hospital, and a member of Tau Beta Pi and Sigma Xi. He retired from the Consolidated Edison Company in 1946.

Paul Gibson Burton (A '95, M '13, F '16, Member for Life), who retired in 1935 as General Plant Manager of the Chesapeake and Potomac Telephone Company, Washington, D. C., died November 14, 1949. Mr. Burton's 41-year career with the Bell System began in 1894 with the Western

Electric Company in New York, N. Y. Transferred to the Switchboard Installation Department in 1898, he worked at preparing specifications, later being placed in charge of the Installation Forces in the Philadelphia District. Two years afterward, he was made Assistant Superintendent of the Installation Department and given supervision of all work in the eastern part of the United States. He resigned from this post in 1904 to become Superintendent of Maintenance for the Chesapeake and Potomac Telephone Company. The following year, he was designated Plant Superintendent of the firm's Washington Division. During the seven years he held this position the number of telephones in the division was increased from 15,000 to 45,000, necessitating an expenditure of more than $4,000,000. He held his next post of Engineer until 1920, when he was named Division Superintendent of Plant. In 1927, he was made General Plant Superintendent, this title being changed to General Plant Manager two years later. Born in Albany, N. Y., June 19, 1870, Mr. Burton was a charter member of the Washington Society of Engineers and served as Chairman of the AIEE Washington Section for the term 1907–8.

Henry Peter Clausen (A '03, M '03, Member for Life), inventor of telephone apparatus and retired electrical engineer, died December 20, 1949, in White Plains, N. Y. Born in Omaha, Nebr., April 12, 1870, Mr. Clausen worked as an engineer for independent telephone companies in Chicago and 55 years ago came East to work for the Western Electric Company and the Stromberg-Carlson Company. For many years, he was in the employ of the American Telephone and Telegraph Company, the Bell Telephone Laboratories, and the International Telephone and Telegraph Company. He helped to obtain 360 patents in this country, and many others in Mexico, Canada, South America, Europe, and Asia. Retiring from the telephone field 20 years ago, Mr. Clausen worked for an insulation company and later the Gray Manufacturing Company of Hartford, Conn. Mr. Clausen was also an active member of the Telephone Pioneers.

William Gordon Stearns (A '35, Member for Life), who had been Sales Representative for the Okonite Company, the Okonite-Callender Cable Company, and the Hazard Insulated Wire Works, died January 3, 1950, in San Francisco, Calif. A native of San Francisco, born January 10, 1875, Mr. Stearns' earliest business experience was with the American Steel and Wire Company. Nearly twenty years of his career were spent with the Underground Cable Company at Portland, Oreg. From 1910 to 1915, he was Sales Manager of the firm, and from 1915 to 1928, he acted as Special Representative for the company in San Francisco. In 1929, he was designated Senior Representative and Sales Manager of the Standard Underground Cable Company. One year later, he became Manager of the San Francisco territory of the General Cable Corporation. Mr. Stearns became a member of the sales staff of the Okonite Company in 1934.

James William Ferguson (A '40), Superintendent of Inside Construction for the City of Seattle (Wash.) Lighting Department until his retirement two years ago, died January 3, 1950, at Seattle. Born in Kansas City, Mo., November 28, 1879, he joined City Light in 1906 as an electrical machinist doing general construction and maintenance work. Rising to General Foreman in 1914, he was designated Superintendent of Inside Construction in 1929. During his career with the utility, Mr. Ferguson supervised the building of many City Light substations.

MEMBERSHIP • • • •

Recommended for Transfer

The Board of Examiners at its meeting of January 19, 1950, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

DeWeese, F. C., genl. engr., Carolina Pr. & Lt. Co., Raleigh N. C.
Little, D. G., consulting engr., electronics & X-ray div., Westinghouse Elec. Corp., Baltimore, Md.
Lovett, I. H., chairman, elec. engg. dept., School of Mines, Univ. of Missouri, Rolla, Mo.
Miller, O. J., vice-pres. & genl. mgr., Duke Power Co., Charlotte, N. C.
O'Banion, A. L., supt., fire alarm div., City of Boston, Mass.
Pingree, G. N., transformer specialist, General Elec. Co., Dallas, Tex.
Rader, R., elec. engr., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Troxel, F. D., partner & chief engr., Vern E. Alden Co., Chicago, Ill.

8 to grade of Fellow

To Grade of Member

Adler, G. H., asst. div. operating supt., Public Service Co. of Northern Ill., Maywood, Ill.
Ankenbrandt, O. F., operating staff engr., The Ohio Bell Tel. Co., Cleveland, Ohio
Arents, C. A., asst. dean of engg., Illinois Institute of Technology, Chicago, Ill.
Austry, W. H., elec. engr., Stackpole Carbon Co., St. Marys, Pa.
Blaskett, S. N., product engr., Elliott Co., Ridgway, Pa.
Bradford, E. L., relay engr., Eastern Shore Public Service Co., Salisbury, Md.
Chadha, N. S., civilian workshop officer, Equipment Workshops, I.E.M.E., Kankinara, Bengal, West India
Conangle, A., requisition engr., I-T-E Circuit Breaker Co., Phila., Pa.
Dehnugara, P. P., engr. in chg., engg. & contracts dept., The English Elec. Co., Ltd., Bombay, India.
Dubbe, E. C., elec. engg. instructor, West Virginia Univ., Morgantown, W. Va.
Duffy, P. A., Jr., design engr., Westinghouse Elec. Corp., Baltimore, Md.
Elble, C. W., elec. engr., St. Croix Paper Co., Woodland, Maine
Easterday, V. I., mech. & elec. engr., Northern Indiana Public Service Co., Hammond, Ind.
Erickson, A. J., div. elec. engr., The Kellex Corp., Richland, Wash.
Foley, W. R., engr. in chg., Kingsville Monitoring Sta., FCC., Kingsville, Tex.
Fordham, L. D., div. engr., Public Service Co. of Northern Indiana, Glencoe, Ill.
Graham, Q., vice-pres., Elliott Co., Ridgway, Pa.
Hammerschmidt, G. L., substation engr., Northern Indiana Public Service Co., Hammond, Ind.
Harvey, N. L., head of applied science, Sylvania Elec. Products, Bayside, N. Y.
Hieronymus, J. W., power supt., Public Service Co. of Northern Illinois, Joliet, Ill.
Hull, V. O., elec. engr., Southern Ohio Electric Co., Columbus, Ohio
Johnson, A. B., field tests engr., Public Service Co. of Northern Illinois, Maywood, Ill.
Kunz, L. C., Jr., section engr., General Electric Co., Schenectady, N. Y.
Larson, M. N., engr., Public Service Co. of Northern Illinois, Chicago, Ill.
Lewis, W. J., development engr., The Ohio Brass Co., Mansfield, Ohio
Lomis, I. C., supervising elec. engr., United Engineers & Constructors, Inc., Philadelphia, Pa.
McGonegle, R. J., maintenance engr., Toledo Edison Co., Toledo, Ohio
McGowan, L. F., engr., New York State Electric & Gas Corp., Binghamton, N. Y.
Noren, H. E., asst. engr. of tests, Public Service Co. of Northern Illinois, Maywood, Ill.
Okey, P., owner, The Okey Mfg. Co., Columbus, Ohio
Osterberg, E. K., engr., Illinois Bell Tel. Co., Chicago, Ill.
Pettit, J. A., Jr., asst. elec. engr., Underwriters Laboratories, Inc., New York, N. Y.
Raymer, D. R., design engr., E. R. Little Co., Inc., Detroit, Mich.
Read, R. F., chief, marketing & sales div., South Platte District, U. S. Bureau of Reclamation, Denver, Colo.
Ricketts, G. B. S., supt. elec. maintenance & construction, Mathieson Chemical Corp., Lake Charles, La.
Robbins, R. D., engr., Illinois Bell Tel. Co., Chicago, Ill.
Schneider, J. H., section engr., DC machines, Elliott Co., Ridgway, Pa.
Seibel, R. C., assoc. prof., elec. engg., Montana State College, Bozeman, Mont.
Sensintaffar, R. M., district power mgr., U. S. Bureau of Reclamation, Casper, Wyo.
Smart, W. R., power apparatus specialist, General Elec. Supply Corp., Cleveland, Ohio
Smith, J. C., asst. elec. engr., Public Service Co. of Northern Ill., Glencoe, Ill.
Sorensen, A. A., chief, elec. equip. sec. engr., Research & Development Laboratories, Ft. Belvoir, Va.
Stanbridge, C. H., consulting engr., Box 1004, Port Elizabeth, South Africa
Stoller, M. J., aeronautical research scientist, National Advisory Comm. for Aeronautics, Langley Air Force Base, Va.
Studley, J. H., elec. supt., Aluminum Co. of America, Alcoa, Tenn.
Sturgis, B. K., engr., I-T-E Circuit Breaker Co., Phila., Pa.
Tucker, S. A., chief engr., Tucker & Co., New York, N. Y.
Williamson, R. A., mgr., railroad rolling stock div., General Electric Co., Erie, Pa.

48 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before March 25, 1950, or May 25, 1950, if the applicant resides outside of the United States, Canada, or Mexico.

To the Grade of Member

Aldcroft, G., German & Milne, Montreal, Quebec, Canada
Alrich, J. D. (re-election), General Elec. Co., Erie, Pa.
Baumhardt, G. L. R., Redmond Co., Inc., Owosso, Mich.
Benson, I. C., Elec. Machinery Mfg. Co., Minneapolis, Minn.
Bradburn, J. R., Consolidated Engg. Corp., Pasadena, Calif.
Bradley, F. T. H., Basrah Petroleum Co., Basrah, Iraq
Cooper, P., Bureau of Yards & Docks, Washington, D. C.
Dancey, W. A., Bell Tel. Co. of Canada, Toronto, Ontario, Canada
Dohl, A. P., Phillips Elec. Co., East St. Louis, Ill.
Duffy, E. C., Long Island Lighting Co., Mineola, N. Y.
Durham, E. E., Cutler-Hammer, Inc., Cincinnati, Ohio
El-Said, M. A. H., Fouad I Univ., Cairo, Egypt
Enns, J. H., Univ. of Michigan, Ann Arbor, Mich.
Evans, R., Army Apprentices School, Harrogate, Yorkshire, England
Guthrie, W., Strain & Robertson, Glasgow, Scotland
Maling, H. F., Jr., U. S. Naval Academy, Annapolis, Md.
McKinney, E. G., Cooke County Elec. Coop., Muenster, Tex.
McLellan, M. L., Northwestern Bell Tel. Co., Des Moines, Iowa
Nagpaul, J. C., 508 Comd Ieme Workshop, Allahabad (U. P.), India
Page, F. L., The Ohio Public Service Co., Port Clinton, Ohio
Palmer, T. E., S & C Elec. Co., Chicago, Ill.
Petch, H. S., London Electricity Board, London, England
Philippoff, J. D., 1385 Regent St., Schenectady, N. Y.
Quirk, W. B., Southern New England Tel. Co., New Haven, Conn.
Razmara, R., Jackson & Moreland Engrs., Boston, Mass.
Ryan, R. M. (re-election), General Elec. Co., Chicago, Ill.
Saunders, N. H., Kellogg Switchboard & Supply Co., Chicago, Ill.
Schlottere, E. L., Philadelphia Elec. Co., Philadelphia, Pa.
Schultz, M. A., Westinghouse Atomic Power Div., Pittsburgh, Pa.
Secrest, W. J., Firestone Tire & Rubber Co., Akron, Ohio
Sen, A. B., Central Public Works Dept., Calcutta, India
Tankersley, C. E., Georgia Power Co., Atlanta, Ga.
Teare, P. H., H. K. Ferguson Co., Cleveland, Ohio
Trindle, J. W., Calif. Tech. Jet Propulsion Lab., Pasadena, Calif.
Viele, S. M., Pennsylvania Railroad, Philadelphia, Pa.
Whistler, J. P., Pacific Tel. & Tel. Co., Los Angeles, Calif.
Yurgelun, E. C., Forstmann Woolen Co., Passaic, N. J.

37 to grade of Member

OF CURRENT INTEREST

Deadline for EJC Engineering Survey Is March 15; 60 Per Cent Have Replied

March 15, 1950, has been announced as the closing date for the nation-wide survey of selected engineering personnel now being sponsored by the Engineers Joint Council for the United States Office of Naval Research. To date over 60 per cent of the 115,000 questionnaires sent to full members of 18 national engineering societies have been answered. After processing by The American Society of Mechanical Engineers, contracting agent under an ONR agreement, the questionnaires will be kept in Washington as a source file of the nation's key engineers and scientists.

A national asset, the body of facts gathered by the survey will be available to Government agencies, private industrial, educational, and professional society planning groups, and for other legitimate purposes.

Those who have not yet answered the questionnaire are urged to do so before the March 15 deadline so that they may be listed among engineering resources of the nation. An interesting fact disclosed by the EJC is that although the first mailing of the questionnaire was to 97,000 senior engineers, these men gave the names of 18,400 other upper echelon engineers and recommended that they also be polled.

The survey was initiated as the result of a conference held in Washington late in 1948 attended by EJC representatives and those of many other engineering agencies, at which the need was discussed for a list of key engineers working in research, development, and other scientific projects, who could be called in on a full or part time basis to work on the broad scientific programs of the National Military Establishment. The results of this survey are not to be construed, however, as an employment register.

The survey is managed by the EJC Committee. C. E. Davies, secretary of ASME, is chairman and R. A. Wentworth, member of ASME, is survey director. Other members of EJC are: AIEE, American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, and American Institute of Chemical Engineers.

Future Meetings of Other Societies

American Electroplaters' Society. Fourth International Electrodeposition Conference. June 12–16, 1950, Statler Hotel, Boston, Mass.

American Society for Testing Materials. 53d Annual Meeting and 9th Exhibit of Testing Apparatus and Equipment. June 26–30, 1950, Atlantic City, N. J.

American Society of Tool Engineers. Industrial Cost-Cutting Exposition. April 10–14, 1950, Convention Hall Buildings, Philadelphia, Pa.

Armed Forces Communications Association. 1950 Annual Meeting. May 12, 1950, New York, N. Y.; May 13, 1950, Fort Monmouth, N. J.

British Industries Fair. Engineering Section. May 8–19, 1950, Castle Bromwich, Birmingham, England.

Institution of Electrical Engineers. Convention on Electric Railway Traction. March 20–23, 1950, London, England.

Midwest Power Conference. April 5–7, 1950, Sherman Hotel, Chicago, Ill.

National Association of Broadcasters. Fourth Annual Engineering Conference. April 12–15, 1950, Stevens Hotel, Chicago, Ill.

National Association of Corrosion Engineers. Sixth Annual Conference. April 4–7, 1950, Jefferson Hotel, St. Louis, Mo.

National Electrical Manufacturers Association. March 13–16, 1950, Edgewater Beach Hotel, Chicago, Ill.

National Petroleum Association. April 12–14, 1950, Hotel Cleveland, Cleveland, Ohio

New Jersey Society of Professional Engineers. Annual Convention. April 14–15, 1950, Essex House, Newark, N. J.

Protective Relay Engineers. Third Annual Conference. March 20–22, 1950, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Tex.

Refrigeration Manufacturers of America—Refrigeration Service Engineers Society. 1950 Midwest Refrigeration and Air Conditioning Educational Exhibit and Conference. May 25–28, 1950, New Hotel Jefferson, St. Louis, Mo.

Society of the Plastics Industry. Fourth National Plastics Exposition. March 28–31, 1950, Navy Pier, Chicago, Ill.

Army Signal Corps Developing Durable Miniature Equipment

Small, lightweight Army Signal Corps equipment which can be easily carried by men and can withstand extremes of climate is being designed to provide fast, effective communications networks for combat troops in the field, the Department of the Army announced.

A crystal rectifier reduced to the size of a match head, a field switchboard that weighs but 22 pounds, and a portable teleprinter weighing 45 pounds are among items developed through Signal Corps research projects. Both miniature and subminiature radio tubes have also been produced.

"Miniaturization" is the word used to describe the task of developing materiel which can be handled with greater facility and less personnel than similar equipment used during World War II. The new products will also provide added protection for soldiers working under combat conditions. In the past, Signal Corps troops have had to work on occasion with equipment which was both cumbersome and conspicuous.

The field switchboard designed by the Army may be used for both wire and radio circuits. Its weight of 22 pounds compares with a 72-pound switchboard currently in use. The new board takes up four-tenths of a cubic foot as compared with two cubic feet for the older type. Three switchboards, each with a capacity of 12 lines, can be connected to provide switching for 36 circuits.

The new portable teleprinter, having a weight of 45 pounds, will eventually replace equipment weighing 225 pounds. The newly developed teleprinter is considered faster and stronger than its predecessor.

During World War II field wire used by the Army weighed 132 pounds a mile. Recent research has resulted in development of wire which weighs only 48 pounds per mile. Approximately 3,928,000 miles of field wire was produced for the Signal Corps between December 7, 1941, and V-J Day. The lighter wire has a talking range, when wet, of 12 miles, as compared with a 10-mile range of field wire currently in use.

The Signal Corps has found 400-cycle alternating current permits the use of smaller and lighter components in much of its electronics equipment. It was also learned that 400-cycle generators themselves could be made smaller and lighter than 60-cycle equipment, for the same power output. Engineers have developed a generator weighing but 85 pounds that puts out as much power as an older piece of equipment weighing 120 pounds. As a conservative generalization on power supplies, the engineers say they are effecting an over-all reduction in size and weight of 25 per cent.

Meggers Heads Optical Society; Brode Named to Edit Journal

Dr. William F. Meggers, Chief of the Spectroscopy Section of the National Bureau of Standards, has been elected President of the Optical Society of America at the society's 34th annual meeting.

At the same time, it was announced that Dr. Wallace R. Brode, internationally known chemist and Associate Director of the National Bureau of Standards, has been elected Editor of the *Journal* of the Optical Society of America to succeed Dean George R. Harrison who has served as editor for the past ten years.

Dr. Meggers has made extensive contributions to the establishment of standard wave lengths in optical spectra, to the descriptions of atomic and molecular spectra, classifications of spectral lines, and spectrochemical analysis. In 1947 he was awarded the Ives Medal of the Optical Society for "distinguished work in optics," and since 1947 has been Vice-President of the Optical Society. Dr. Meggers has been at the Bureau of Standards since 1914 and head of the Spectroscopy Section since 1920.

At the Bureau of Standards, Dr. Brode is responsible for the work of those laboratories conducting research in the fields of chemistry, metallurgy, and mineral products. Dr. Brode is chairman of the educational committee which supervises the Bureau's graduate school and part-time training program.

MIT Develops Cathode-Ray Process for Sterilizing of Packaged Drugs

Recent development at the Massachusetts Institute of Technology of a process for sterilizing a wide variety of pharmaceuticals after their final packaging by means of high-voltage cathode rays now makes practical the irradiation of heat-sensitive products.

Produced in an electrostatic generator at MIT, 3,000,000-volt cathode rays (similar to X rays but vastly more penetrating) have been directed at a wide variety of important pharmaceutical products during the past year in studies under the direction of Dr. John G. Trump, Associate Professor of Electrical Engineering, and with the co-operation of the MIT Department of Food Technology.

Dr. Trump and his associates report that penicillin, streptomycin, surgical sutures. anticoagulents (such as heparin), and many other substances can be sterilized in their final sealed glass containers without detectable adverse effect on their potency or other properties. It is stated that the amount of cathode-ray energy which will completely destroy all bacterial and virus contaminants raises the temperature of the pharmaceutical less than eight degrees.

This work is one part of continuing studies of high-voltage X rays in the Electrical Engineering Department and Laboratory for Nuclear Science and Engineering at MIT. The entire program is an outgrowth of the development of the nation's first high-voltage electrostatic generator, built at MIT in 1933 by Dr. Robert J. Van de Graaff, now Associate Professor of Physics.

First Industrial Mercury Turbine Installed at G-E in Pittsfield

The General Electric Company has announced completion of what is believed to be the country's only industrial installation of a mercury-turbine electric power generating unit. The equipment will supply power and heat to the company's Transformer and Allied Product Divisions plant in Pittsfield, Mass.

The 7,500-kw mercury-turbine, which was added to an existing steam station, will increase generating capacity by one-half and will add one-third to the steam supply used to heat factory and office buildings at the plant. This increase in capacity will not require the use of any additional cooling water, General Electric engineers said.

Included in the system is a mercury boiler, a mercury-turbine generator, and two condenser boilers. Pulverized coal is burned in the boiler to vaporize the mercury which is then run through the mercury turbine which in turn runs electric generators. After the mercury vapor has passed through the turbine, it goes into the condenser boiler where enough heat is given off to turn water into high-pressure steam.

Steam obtained as a by-product of the power-generating operation will amount to more than 120,000 pounds per hour. This steam will be used in conventional steam turbines to generate approximately 11,500 kw of electricity and, in addition, will supply heat for the buildings.

Although coal will be used for normal power plant operations, a large oil tank also has been installed to hold liquid fuel for emergencies.

To house the new equipment, General Electric has expanded and remodeled its power station. The station now has a normal capacity of 22,500 kw plus an emergency standby capacity of 5,000 kw and would be capable of supplying normal electric requirements of a city of more than 50,000 people.

Multichannel Recorder Fosters Air Safety

Recently unveiled at the Airwave Communications Conference held in Cleveland, Ohio, was this Multichannel Airport Recorder, capable of recording 14 separate air-to-ground conversations simultaneously on magnetic tape 7/10 inch wide. Expected to eliminate much controversial testimony as to the causes of air crashes, the equipment is manufactured by the Brush Development Company and has been approved by the Civil Aeronautics Authority. The complete recorder mounts on three 7½-foot standard relay racks. The first rack includes two complete tape transport mechanisms and the master recorder control panel. The second rack contains a third tape transport mechanism and the complete electronic setup for the entire recorder. The third rack holds the playback and speaker unit. The recorder gives eight hours of unattended operation

G-E Train of Electric Exhibits Will Be Sent on National Tour

The "More Power to America Special," first train of its kind in industrial history, will be launched on a nation-wide tour this spring by the General Electric Company's Apparatus Department.

Exhibits of more than 2,000 electrical products, processes, and techniques ranging from precise aircraft instruments to complex working models of steel mill, textile, and other industry equipment, will be displayed throughout nine cars of the special exhibition train.

C. H. Lang, Vice-President in charge of sales for the company's Apparatus Department, said the train will visit the country's key industrial centers for inspection by utility and industrial executives and municipal leaders. Since it is an industrial development enterprise, it will not be open to the general public.

A special group—the Apparatus Exhibit Train Division—was set up early last year with responsibility for preparation and operation of the train. This division is managed by C. P. Fisher, Jr.

The displays will portray the latest advances in power generation and methods and equipment for the profitable use of electricity throughout all industry. They have been designed especially for those who produce electric power and for those who put this power to work in industry and the community.

Included in the exhibits will be turbines of all types—steam, gas, and mercury; equipment for transmitting and distributing electric power; and motors and controls engineered into combinations that can perform a wide variety of industrial operations.

Other displays will include precise measuring and recording instruments; new developments for community improvement, such as street lighting and sewage treatment equipment; and products which contribute to national security.

The train will be hauled by an Alco-G-E 2-unit 4,000-horsepower diesel-electric locomotive which itself will be part of the series of displays.

GE's Two-Millionth-of-a-Second Photolight

Pictures having exposures of a few millionths of a second are of immeasurable aid in the study of missiles in flight. However, the fastest camera shutters can only cut exposure time down to about one-thousandth of a second, which is long enough for an Army rifle bullet to travel almost two feet. Hence, exposures in the millionth-of-a-second range must be made with quick flashes of light rather than by means of fast shutters. Here, the action of the G-E photolight is illustrated. A .22-calibre bullet smashed through a glass jar, then broke the electric conductor to take this picture. Breaking of the conductor set off a high-speed photolight, exposing the action for two millionths of a second

Patent Classification Index on Welding Compiled by Ohio State

The Department of Welding Engineering at Ohio State University, Columbus, has announced completion of a new Patent Classification Index in the A. F. Davis Welding Library, designed to make information on more than 12,000 United States patents on welding more easily available to industry and educational institutions.

Each patent in the library is classified or indexed in several different ways—by process, material, product, use, inventor's name, date of issue, and so forth, on a single keysort card. These cards are sorted mechanically, and in very little time the numbers of patents pertaining to a given field may be determined.

The patents are divided into the 19 groups: (1) Arc Welding and Testing Procedure (2) Arc Welding Equipment (3) Arc Welding Electrodes, Welding Rods (4) Electrode Holders, Welding Shields, Accessories (5) Oxy-Fuel Gas Welding, Cutting, Heating, and Deseaming (6) Forge, Furnace, and Thermit Welding: Soldering (7) Butt, Flash, and Stud Welding, Induction (8) Spot, Seam, and Projection Welding (9) Aircraft (10) Containers, Pressure Vessels, Chemical Plant (11) Electrical Industry (12) Farming Industry, Earth-Moving, Mining (13) Links, Chains, Rings, Bands, Hoops, Wheels, Wire (14) Motor Vehicles, Automotive Industry (15) Pipes and Tubes (16) Railroad (17) Structural Welding, Furniture (18) Watercraft and Water Power (19) Miscellaneous Industrial Applications.

The index covers not only the fundamental patents on welding processes and equipment but also the very important field of industrial applications of the welding processes.

Essentially, the type of information made available through the system is in the form of patent numbers relating to a designated area. Interested industrial organizations then may order those patent specifications from the patent office and refer to the material covered. The patent specifications are on file in the Davis Library and may be consulted by anyone making a search in person.

The great advantage of the Patent Index is the speed with which relevant patent numbers may be obtained. Most of the searches can be accomplished in from 3 to 20 minutes, and their value is limited only by the completeness of the patent file. Work will proceed for a number of years to expand and complete the listing of all patents relating to the welding field, according to Professor Robert S. Green, Acting Chairman of the university's Welding Engineering Department.

The use of the patent classification system is offered to industrial organizations, individuals, and educational institutions. Services are free of charge to those who make use of the index system in person, but modest charges to defray clerical expense will be made for inquiries handled by mail.

New York Convention of IRE to Feature Presentation of Awards

Among those slated to receive awards for outstanding work in electronics at the forthcoming annual convention of the Institute of Radio Engineers to be held in New York, N. Y., March 6–9, at the Hotel Commodore and the Grand Central Palace, are Otto H. Schade, Andrew V. Haeff, Joseph F. Hull, Arthur W. Randals, and E. J. Barlow.

Otto H. Schade, research engineer for the Radio Corporation of America Victor Division of Harrison, N. J., is the recipient of the 1950 Morris Liebmann Memorial Prize. The award is given to Mr. Schade for his outstanding contributions to the analysis, measurement technique, and system development in the field of television and related optics.

Andrew V. Haeff, Consultant with the Naval Research Laboratory, Washington, D. C., is the recipient of the Institute of Radio Engineers' Harry Diamond Memorial Award for 1950. It will be conferred for his general work in the field of high-frequency radio analysis, on the traveling-wave tube, and on memory storage devices. The Harry Diamond Award is given annually by The Institute of Radio Engineers for outstanding contribution in the field of radio or electronics by a person or persons in the Government service, as evidenced by publication in the professional society journals.

Recipients of the 1950 Browder J. Thompson Memorial Prize are Joseph F. Hull, research engineer, and Arthur W. Randals, research physicist. Both are civilian staff members of the United States Army Signal Corps. They have been named for the award for their paper entitled "High-Power Interdigital Magnetrons," published in the November 1948 issue of *Proceedings of the Institute of Radio Engineers.*

E. J. Barlow, Consultant in advanced development of klystrons and radar systems, has been announced as the 1950 winner of the Editor's Award of the Institute of Radio Engineers.

The annual award will be accompanied by the following citation; "To E. J. Barlow for an unusually clear presentation of a technical subject in his paper, 'Doppler Radar,' published in the April 1949 issue of *Proceedings of the Institute of Radio Engineers.*"

Electric Railway Traction to Be Subject of British IEE Meeting

The Traction Technical Committee of the British Institution of Electrical Engineers acting on behalf of The Council, and in collaboration with members and others professionally engaged with British Railways and Industry, have arranged a Convention on Electric Railway Traction to be held in The Institution Building, March 20–23, 1950, in London, England.

The convention, which will be opened by the President of The Institution, will comprise an opening meeting and six technical sessions, and its object will be to present the latest views and practices in electric railway traction and to reveal the achievements and capabilities of British engineers and the British electric industry in the field of railway electrification and diesel-electric traction.

At the opening meeting and in one of the technical sessions both the practice of British Railways and London Transport will be covered. This session will include a paper on the electric equipment recently installed on the London-Shenfield Line and will conclude with a general review of the achievements of British engineering in overseas railway electrification.

The opening lecture and the 30 papers to be presented at the convention, with the discussions, will subsequently be published in a special issue of the *Proceedings* of The Institution.

Lehigh's New Program Gives Grads EE and ME in Five Years

Adoption of two new 5-year educational programs by the Lehigh University faculty, effective immediately, has been announced by Dr. Martin D. Whitaker, President of the university.

The first 5-year curriculum will offer the degree of Bachelor of Science in mechanical engineering at the end of four years and that of Bachelor of Science in electrical engineering at the end of the fifth year.

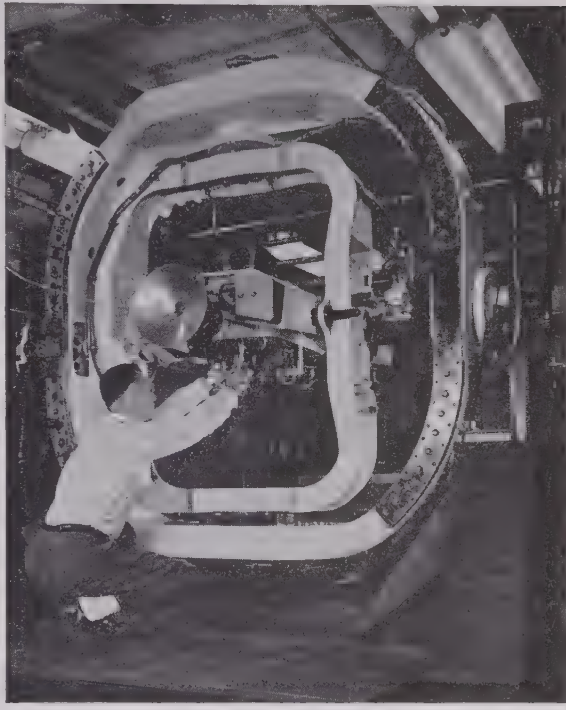
The second new curriculum will give a student the opportunity to receive the degree of Bachelor of Science in industrial engineering at the end of four years and that of Bachelor of Science in business administration at the end of the fifth year.

In establishing the combined electrical and mechanical engineering 5-year program, the educational policy committee of the faculty reported that the engineering work of electrical manufacturers and public utilities in the power field is almost equally electrical and mechanical.

Explaining the combined electrical–mechanical project, Loyal V. Bewley, head of the department of electrical engineering, said today that it is impossible to design an electric machine or a power plant without encountering as many mechanical as electrical problems.

The proposed 5-year curriculum makes use of existing undergraduate courses now offered at Lehigh. It will be possible for a student to change to any of the three standard electrical engineering options—power, communications, or general—at the end of his junior year. The curriculum has been established in such sequence that in the event the student finds it impossible for financial or other reasons to complete the 5-year program, he will receive a degree in mechanical engineering upon completion of four years of study.

Flight Simulator Tests Aircraft Design



Because this gimbal frame will simulate the motions of an aircraft in flight, the calculator of which it is a part is dubbed the "flight simulator." Developed by the Massachusetts Institute of Technology, the computer can be used to "flight-test" an airplane in the design stage. A problem is worked out on the apparatus by setting electronic computer dials to represent such characteristics as weight, velocity, altitude, and wing span. These properties are obtained from wind-tunnel test data on small models of the proposed aircraft. Motions of the gimbal frame table, and thus the actions of the hypothetical rocket or plane in flight, are recorded on charts. The gimbals are suspended so that they can tilt in any direction

Brazil's First TV Transmitter Will Be Erected in São Paulo

Brazil's largest radio network—Emissoras Associadas—plans to introduce television at the fast-growing business center of São Paulo, and all equipment will be supplied by the Radio Corporation of America, it has been announced by Meade Brunet, a Vice-President of RCA and Managing Director of the RCA International Division. He said the station is expected to be on the air in the summer of 1950.

Arrangements for the installation of the television transmitter, as well as associated studio and mobile pickup equipment, were begun in 1948 and concluded during the recent visit to the United States by Dr. Assis Chateaubriand, Director General of the Brazilian network. The transmitter and antenna will be located atop São Paulo's highest edifice, the State Bank Building.

The installation will include what is known as a 3-bay super-turnstile antenna which is to be 520 feet above street level and which is capable of radiating 20 kw of power. New studios now are under construction in a São Paulo suburb called Sumare. Since the city's power supply is of 60 cycles, it will be possible to use United States television standards of 525 lines and 60 fields. The station frequency band will be on channel number 3.

Provisions are being made for the use of microwave transmitting equipment between the studio, outdoor mobile pickup units, and the main transmitter. The contract providing for the installation was arranged through RCA Victor Radio, S. A., the Brazilian associated company of RCA.

Better Electronic Components Is Theme of Coming Joint Conference

A 3-day conference sponsored by the AIEE, Institute of Radio Engineers, Radio Manufacturers Association, and with the co-operation of the military services, the Research and Development Board of the Department of Defense, and the National Bureau of Standards will be held May 9 through 11 at Washington, D. C.

Purpose of the conference will be to discuss improved quality components for greater dependability of radio-electronic equipments, unitized packaging as a means of simplified maintenance, miniaturization, and circuit elements suitable for unit package design. These topics will be discussed from the viewpoint of military equipments, commercial aviation, industrial instrument and control, commercial radio and television, and mobile communications equipments.

Advance registration for the conference may be obtained by sending $2 to A. E. Zdobysz, Bureau of Aeronautics, Building W, Room 1W91, Navy Department, Washington 25, D. C. Reservations for copies of the report of the conference may be made before May 9 through Mr. Zdobysz, Treasurer of the conference, or through R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y., either before or after the conference.

Farm Journal Competition to Promote Rural Electrification

Five cash awards amounting to $1,000 and five engraved plaques, known as the Frank Watts Awards, will be made annually by *Farm Journal* magazine "to stimulate the promotion and sale of electrically operated farm equipment as a means of improving agricultural productive efficiency," it is announced by Graham Patterson, publisher of the magazine.

Cash prizes of $300, $250, and three of $150 each will go to the farm departments of electrical operating company organizations, while the plaques will be awarded to the winning companies. The plaques will read "For excellence in promoting farm electrification as a productive force for better farming and better living."

The awards are named for Frank Watts in recognition of his contributions to farm electrification. For the last nine years, he has been associated with *Farm Journal* magazine.

The Edison Electric Institute, New York, N. Y., will administer the awards, which will be presented for the first time in April 1951 for work done in 1950.

White Heads Air Radio Group. Richard White, Manager of Electronics Engineering for Trans World Airline, has been appointed chairman of the International Air Transport Association Radio Aids Technical Group. The group, which includes members from nearly all international air-line operators, was set up to study radio navigational aids throughout the world and to make technical recommendations to IATA, leading to world-wide standardization of radio navigation and related equipment.

NAB-FMA Merger. Proposals of a Liaison Committee between the National Association of Broadcasters and the Frequency Modulation Association that the two organizations be combined have been approved by the Boards of Directors of both groups. A highlight of the merger agreement includes the establishment in NAB of an FM Department to function under supervision of an FM Executive Committee which will consist of three members of FMA's Board of Directors and two from the NAB Board. Another provision states that the department will have a full-time paid director to be appointed by NAB President Justin D. Miller. In accepting the merger offer, FMA's board recommended that Edward L. Sellers, executive director of FMA, be named to head the new department.

SMPE Changes Name. Effective January 1, 1950, the name of the Society of Motion Picture Engineers was officially changed to the Society of Motion Picture and Television Engineers. Endorsed originally by the Board of Governors of the society in June 1949, and discussed at the business meeting during the SMPE fall convention in Hollywood, Calif., the change of name was then submitted as a proposal to the entire voting membership by letter ballot in November, and was approved by an overwhelming majority. Outstanding among the reasons for the change are the increasing mutual interests of technical people in both motion pictures and television, as well as the society's active participation in the development of new television techniques, such as its new test film for television station use. In addition, the society has filed a brief with the Federal Communications Commission proposing specifications for a nation-wide theater television system.

KGSE Ripley Generating Station Completed. Open House ceremonies last fall, during which a new 30,000-kw turbogenerator was formally placed in operation, marked official completion of the Kansas Gas and Electric Company's Ripley Station, located in Wichita. Ripley and its initial generating unit of 30,000 kw was dedicated in 1938. A second 30,000-kw generator was added in 1948. The third unit boosts Ripley's capacity to 90,000 kw, making it Kansas' largest generating station.

Gustafson Resigns AEC Post. John K. Gustafson has completed the 2-year period during which he agreed to serve as Manager of the Atomic Energy Commission's Raw Materials Operations Office, and left that post January 1, 1950. Succeeded by his present deputy, Jesse C. Johnson, Dr. Gustafson was named Consulting Geologist of the M. A. Hanna Company of Cleveland, Ohio. During his tour of duty with the AEC, Dr. Gustafson had been in charge of the negotiations and operating arrangements for procuring ores from sources outside the United States and has established and carried on a program for stimulating mining and improving processing of uranium ores in the United States. He will continue to work in the atomic energy program as a consultant to the commission. His successor, Mr. Johnson, has been with the AEC since January 1948. Previously, he had served with the Reconstruction Finance Corporation.

Avery Named ASHVE President. The election of Lester T. Avery, President of the Avery Engineering Company of Cleveland, Ohio, as the 1950 President of the American Society of Heating and Ventilating Engineers was announced at the society's 56th annual meeting in Dallas, Tex. Other officers elected were: First Vice-President, Lauren E. Seeley, Dean of the College of Technology, University of New Hampshire, Durham, N. H.; Second Vice-President, Ernest Szekely, President, Bayley Blower Company, Milwaukee, Wis.; Treasurer, Reg F. Taylor, Consulting Engineer, Houston, Tex. Mr. Avery succeeds Alfred E. Stacey, Jr., Director of Application Engineering for the Carrier Corporation, Syracuse, N. Y.

Industrial Heating School. An Industrial Heating School for public utility sales representatives under the sponsorship of the Westinghouse Electric Corporation and the Edison Electric Institute will be held March 13–17 at the Summit Hotel, Uniontown, Pa. Purpose of the meeting is to acquaint utility salesman with the nature of industrial heating problems and to familiarize them with the latest developments in the electrical heating art. The first four days of technical sessions will be followed by an inspection trip on Friday, March 17, to the East Pittsburgh plant of the Westinghouse Electric Corporation. Here, all the heating applications discussed at the school will be seen in actual operation. For further information, write P. T. Lagrone, Customer Section, Central Station Sales Department, Westinghouse Electric Corporation, East Pittsburgh.

Midwest Power Conference. The 12th annual 3-day Midwest Power Conference will be held April 5, 6, and 7 at the Sherman Hotel in Chicago, Ill., with a theme of "Economy in Power," it was announced by R. A. Budenholzer, Professor of mechanical engineering at Illinois Institute of Technology and Director of the conference. Twenty-six sessions, including three luncheons and the annual All-Engineers dinner, are scheduled for the program, Budenholzer said. More than 50 papers will be presented by leading authorities in practically every phase of the power industry. The conference is sponsored by Illinois Institute of Technology with the co-operation of nine other Midwestern universities and nine local and national engineering societies. Further information may be obtained from Dr. Budenholzer or Edwin R. Whitehead, Conference Secretary, both of whom are at the Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Carnegie Tech Receives Grant. Carnegie Institute of Technology, Pittsburgh, Pa., has received a $100,000 grant in support of its pioneering educational plan, President Robert E. Doherty announced recently. The grant, made by the Carnegie Corporation of New York, will be given the school in three annual installments to help develop its Carnegie Plan of Professional Education, specifically in the College of Engineering and Science, Dr. Doherty revealed. The Carnegie Corporation of New York has no direct connection with Carnegie Institute of Technology. Until 1946, the corporation was a parent body for the school. But in that year, in accordance with long-range objectives set up in 1921, the corporation increased the Carnegie Tech endowment by eight million dollars and, at that time, ended its responsibility toward the school. Since then, Carnegie has had to compete for corporation funds on the same basis as any other institution.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Power Electronics

To the Editor:

I wish to reply to the letter to the editor by A. G. Benedict on page 1114 of the December 1949 issue regarding the article, "Power Electronics as an Educational Medium" (*EE, Aug '49, pp 647–9*).

It has been my good fortune to study under Professor C. H. Willis. The circuits illustrated in his article were studied in this course. I, therefore, feel qualified to comment on their value as teaching aids.

This study brought clearly to me an awareness of just the conditions Mr. Benedict has enumerated in his letter. But is not this awareness of value? Truly, these circuits would confuse the student equipped only with techniques of steady-state sine wave analysis. This is exactly the point. These circuits require something beyond this and require a definite grasp of the physics involved. It brings home the fact that the mechanics of sine-wave analysis is no substitute for thinking.

I agree with Mr. Benedict that circuit *3*

of Professor Willis' article has danger signs hung on it but it takes insight to see the signs as he has. However, I ask, would a student with no familiarity with such nonlinear circuits see the signs, and if he saw them would he know what to do about it?

Mr. Benedict will know better than I the value of an ability to understand and analyze such nonlinear power systems. (My interest lies in electronics.) If the ability is desirable, then these circuits are excellent teaching mediums.

THOMAS B. BISSETT
(Menlo Park, Calif.)

Engineering Education

To the Editor:

Although I agree with the main thesis of the article, "Design Problems for Engineering Education" (*EE, Jan '50, pp 29–33*), it seems to me that the opening statement is incorrect. Messrs. McEachron and Linville believe that "the problem of providing effective engineering education" has increased in difficulty "as the enrollment in colleges of engineering has increased." While it is true that large enrollments create a physical difficulty, in that a larger physical plant and more instructors are required, the basic problem is of a different nature. The authors recognize this when they say "the practicing engineer must integrate all of his knowledge of separate fields into an effective working combination." This idea of an integrated view of engineering is found to be lacking in the usual undergraduate curriculum.

Engineering education is considerably compartmentized. Various theories, hypotheses, principles, and facts are taught in a somewhat haphazard and unrelated manner, despite the underlying unity of the engineering sciences. Certain branches of science are taken out of context, so to speak, are given titles such as Electrical Engineering, Mechanical Engineering, or Chemical Engineering, and are presented very much "in vacuo." Mathematical methods are developed for handling electrical problems, for instance, but the fact is barely mentioned that the same methods and mathematics are used in studying heat flow or vibration problems.

The prevailing method of teaching engineering, for want of a better name, we may call the "tool" method. It presents to the student a number of apparently distinct units of study: a-c machinery, d-c machinery, thermodynamics, power transmission, radio, chemistry, physics, magnetism, to name a few. One is expected to become thoroughly familiar with each of these unitary entities without regard for any relationships that may exist among them (notwithstanding the fact that a study of comparisons and differences is a valuable aid to learning). After becoming proficient in the use of the "tools," the student is supposed to be capable of using them in shaping any material that may happen to come his way.

It may be argued that, pragmatically speaking, the "tool" method has proved successful. Yet, may it not be that our engineering progress has been made in spite of the method and not because of it? That is, progress has been achieved by engineers who overcame the limitations of the unit system of education and synthesized a whole greater than the sum of its parts.

NORTON SAVAGE (A '41)
(United Engineers and Constructors, Philadelphia, Pa.)

Transmission Line Charts

To the Editor:

My attention was directed recently to a letter to the editor (*EE, Jan '50, pp 93–4*) concerning my article, "Transmission Line Charts" (*EE, Sept '49, pp 767–74*). I wish to thank Mr. Storch for his careful criticism of my presentation, and for showing an alternative method of development of the material. I think that every author who has written on the subject has used a different mathematical route to arrive at the final result. The brevity of Mr. Storch's presentation is not to be denied, but I wonder how many of the readers for whom my paper was intended are as familiar with the circles of Apollonius (or bipolar circles, as they are more often called) as they are with the equation $(x-a)^2+(y-b)^2=c^2$? It is true that every electrical engineer, at some point in his training, is exposed to the solution of the electric or magnetic field problem involving two parallel wires, wherein the resulting field plot has the same construction as the rectangular line chart. However, this analogy may have been forgotten by some of our readers.

If a good knowledge of geometry is presupposed on the part of the reader, the whole development of transmission line charts may be disposed of quite briefly as in the following:

> The input impedance of a short-circuited line of length S may be written as $Z_s=Z_0 \tanh \gamma S$. The geometric solution of the short-circuited line must then be the same as that for the complex hyperbolic tangent, which is well known. By a consideration of the plot of input impedance that results for a short-circuited line with dissipation, and recognizing that a section of short-circuited line may be considered as the load for the remainder of the line, the plot obtained through the foregoing equation may be shown to hold for a line with any kind of termination. Thus the development of the rectangular chart is completed. The form of the Smith chart may then be obtained directly from the properties of the bilinear transformation $\rho=\frac{z-1}{z+1}$.[1]

I doubt that the majority of our readers would be satisfied with such a concise presentation.

I also wish to thank Mr. Storch for pointing out that the general form of the bilinear transformation is applicable to 4-terminal networks in general as well as to transmission lines. I think that this subject has received too little attention in the literature on networks, and that too few engineers are acquainted with the applications of this mathematical tool to network analysis and synthesis. A good tutorial paper on the subject would, in my opinion, be of great value to the beginners in the field.

REFERENCE

1. The Mathematics of Circuit Analysis (book), **E. A. Guillemin.** John Wiley and Sons, New York, N. Y. Pages 360–73.

HERBERT L. KRAUSS (A '42)
(Assistant Professor of Electrical Engineering, Yale University, New Haven, Conn.)

Symbolic Treatment of Sinusoids

To the Editor:

Referring to the article, "Symbolic Nomenclature for Sinusoids" (*EE, Jul '49, pp 561–5*) I would like to point out that G. Giorgi had observed and overcome in 1903[1] the formal difficulties encountered in the vector treatment of alternating currents. Giorgi himself summarized 46 years later[2] his contributions as follows:

> It must be noted that in Steinmetz' notation both the vectors which are representative of the alternating quantities, and their ratios, were represented with complex numbers. This representation is natural for the former, but not for the latter. Vectors are not complex numbers. They may be represented as such without error, assuming that one vector corresponds to the real positive unit quantity, and that the ratios of the other vectors to the first are substituted for the other vectors. But this is artificial, and may cause misunderstandings, because from such representation might result that a certain alternating quantity appears to be real, as a vector with positive square, and that another quantity in quadrature with the first appears as a pure imaginary, with a vector with negative square. Instead, physically, the two alternating quantities are equally real, and this dissymmetry of their properties in fact does not exist.

In his paper 1903,[1] Giorgi denotes with j_x and j_s the two unit vectors along the reference axes. An alternating quantity is denoted by a symbol which represents a geometrical vector, and is never reduced to a numerical quantity, either real or imaginary. Vectors are indicated in print by letters in boldface type, but their ratios (as impedance) by italic type, for instance

$$Z=\frac{\mathbf{E}}{\mathbf{I}}$$

so that all ambiguity is avoided and the notation and treatment of vectors and complex numbers are clearly kept separate.

It is interesting to point out that Giorgi in the same article, as he had done in a previous one,[3] banished the loose usage of the adjective "ohmic." Giorgi states:

> The denomination of *ohmic resistance* should be banished: . . . if "ohmic" signifies "measureable in ohms" this qualification is due also to reactance; if, instead, reference is made to the resistance as discovered by Ohm, this terminology is correct for the resistance which is measured for direct currents, but not for the active resistance measured with alternating current, which in general is something quite different.

REFERENCES

1. The Elementary Methods for the Representation and the Study of Sinusoidal Alternating Quantities, **G. Giorgi.** *L'Elettricista* (Rome, Italy), volume 12, March and June 1903, pages 68–73 and 137–44.

2. Verso l'Elettrotecnica Moderna (Towards Modern Electrical Engineering, book), **G. Giorgi.** Liberia Edtrice Politecnica Cesare Tamburini, Milan, Italy, 1949.

3. Definition of Reactance, **G. Giorgi.** *L'Elettricista* (Rome, Italy), volume 4, January 1895, pages 28–34.

P. A. ABETTI (A '49)
(General Electric Company, Pittsfield, Mass.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

BEZUGSQUELLEN-LEXIKON FÜR DIE SCHWEIZERISCHE ELEKTRIZITÄTS-INDUSTRIE, RÉPERTORIE DES INDUSTRIES ÉLECTRIQUES SUISSES. First edition 1948/1950. Fritz Lindner Verlag, Zürich 37, Switzerland. 405 pages plus 64 pages

ads and index; illustrations, $8^1/_2$ by 6 inches, cloth, 25 Swiss frs. This handbook of the Swiss electrical industry provides the names of the firms in the electrical and radio industries, more than 2,000 items used in all branches of these industries and their manufacturers, and the system of current and voltage used in all Swiss communities which have more than 1,000 inhabitants.

ELECTRIC-LAMP INDUSTRY: TECHNOLOGICAL CHANGE AND ECONOMIC DEVELOPMENT FROM 1800 TO 1947. By A. A. Bright, Jr. Macmillan Company, New York, N. Y., 1949. 526 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $7.50. Focused upon the technological progress of the lamp industry, this book considers the factors which influenced the direction, extent, and timing of the advances in industry in the last 150 years. It discusses the influence of cartels, tariffs, and anti-trust legislation on the process of innovation, along with the effect of the patent system. This is the second of a series of five studies of the economics of science and engineering.

ELECTRICAL TRANSMISSION OF POWER AND SIGNALS. By E. W. Kimbark. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 461 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Of value as a reference book to the professional engineer and as a text in electrical transmission courses, this book presents the basic theory of transmission lines together with applications to all three fields of power, telephony, and ultrahigh frequencies. The theory is given in three main parts: transmission-line parameters, steady-state phenomena, and transient phenomena. Charts, tables, and graphs of the characteristics of various types of conducting lines are included.

EARTH CONDUCTION EFFECTS IN TRANSMISSION SYSTEMS. By E. D. Sunde. D. Van Nostrand Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 373 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5. Primarily concerned with fundamental methods, this book deals with the analysis of earth conduction effects and the principles underlying protective measures against resultant circuit disturbances. Each aspect of earth conduction is presented with a coverage of present knowledge and new material gained from studies made at the Bell Telephone Laboratories.

ELECTRICITY FOR STUDENTS OF SCIENCE AND ENGINEERING. By T. T. Smith. International Textbook Company, Scranton, Pa., 1949. 410 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, fabrikoid, $5. Based on a course in electricity given at the University of Nebraska, this book is written for upperclass undergraduate students who have had a year of general physics and calculus. It starts with the concept of an electric charge and builds up to a discussion of alternating and oscillating currents, long-line transmission, thermionic vacuum-tube circuits, and electric waves.

ELECTRICITY IN THE SERVICE OF MAN. By S. G. Starling, revised by H. J. Gray. Second edition, Longmans, Green and Company, London, England; New York, N. Y.; Toronto, Ontario, Canada; 1949. 255 pages, illustrations, diagrams, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $2.25. Intended for those not specializing in electrical engineering, this book presents a review of the subject of electricity. In simple, nonmathematical terms, it describes and explains the operation of dynamos, electric motors, and transformers; lighting, telegraph, and telephone; electrolysis and batteries. Wireless telegraphy is considered as well as cathode-ray tubes, transient phenomena, and photoelectric cells.

AERIALS FOR METRE AND DECIMETRE WAVELENGTHS. By R. A. Smith. Cambridge University Press, American Branch, New York, N. Y., 1949. 218 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75; 18s. Detailed design considerations are given for aerials for wave lengths from 12 meters to 10 centimeters with the major amount of space devoted to the range from 12 meters to 1 meter. A comprehensive description of all aerial systems has not been attempted, but a limited number of applications have been selected to illustrate general principles. Aerials for wave lengths below ten centimeters are dealt with in another book of the series.

APPLIED MECHANICS. By A. P. Poorman. Fifth edition. McGraw-Hill Book Company, New York, N. Y., 1949. 388 pages, diagrams, charts, tables, $8^1/_4$ by $5^1/_2$ inches, cloth, $4. This standard work on applied mechanics has been revised and brought up to date in this fifth edition. The law of Coriolis and a table of moments of inertia and radii of gyration of a number of simple areas are among the additions made. Loads on structures are now given in kips. The data of all problems are changed, and new problems are added. As in previous editions answers to all problems are given.

BASIC TELEVISION—PRINCIPLES AND SERVICING. By B. Grob. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 596 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $6.50. A thorough background of television theory is presented in this practical video and frequency-modulation receiver servicing manual. Each block of circuits in the receiver is dealt with separately. Direct and projection television, in black and in color, are discussed in detail. Only arithmetic and simple algebra are needed.

CYLINDER PRESSURES AND THEIR INFLUENCE ON DIESEL ENGINE EFFICIENCY. By D. D. Cook, L. J. Grubb, and J. C. Lepic. Cooktite Ring Sales Company, 1737 Howard Avenue, Chicago 26, Ill., 1949. 87 pages, illustrations, diagrams, charts, tables, 11 by $8^1/_4$ inches, paper, $2.50. This booklet discusses the specific factors which affect Diesel engine cylinder pressures and methods for maintaining effective pressures. Instrumentation is described for determining pressure loss, and combustion data are given for a number of specific case histories. Much of the detailed information concerns the use of the company's product.

ELEMENTS OF THERMODYNAMICS AND HEAT TRANSFER. By E. F. Obert. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1949. 372 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. Based on the author's "Thermodynamics," this is a textbook for an undergraduate course in thermodynamics and heat transfer for students of engineering. The text stresses real machines, flow processes, properties of fluids, and the conditions where simplified anlyses can be applied. Definitions are considered first and then the laws and applications. Problems are included at the end of each chapter, and the appendix includes much useful data.

ENGINEERS' DICTIONARY, SPANISH-ENGLISH AND ENGLISH-SPANISH. By L. A. Robb. Second edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 664 pages, $8^1/_2$ by $5^1/_2$ inches, cloth, $12.50. This volume is designed to give the North American technical man the accepted engineering terminology of Spanish America and vice versa. The new edition has been enlarged: to cover more thoroughly electrical and mechanical engineering terminology, including radio and television; to bring all branches of civil engineering up to date, particularly soil mechanics, photogrammetry, and airport construction; and to include the important terms peculiar to mining, shipbuilding, logging, sugar milling, and oil-field operations.

EXPERIMENTAL PHYSICAL CHEMISTRY. By F. Daniels and others. Fourth edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 568 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. The purposes of this combined text and laboratory manual are to illustrate the principles of physical chemistry, to train the student in careful experimentation, to develop familiarity with apparatus, and to encourage ability in research. This revised edition reflects the development of the subject in the past decade and the problems of handling a large number of students in a limited laboratory space. Redesigned apparatus and procedures and new subject fields are included.

FACSIMILE. By C. R. Jones. Murray Hill Books, New York, N. Y., and Toronto, Ontario, Canada, 1949. 422 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, linen, $6. This book provides a single source of available information on modern facsimile methods and systems in the United States. It emphasizes devices and their circuits rather than theory. The operation of available equipment is described in simple terms, and a section on servicing methods is included.

GIANT BRAINS OR MACHINES THAT THINK. By E. C. Berkeley. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 270 pages, diagrams, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $4. Describing several existing large-scale mechanical computers, this book presents their general operating procedure, history, and principles. Future possibilities and their significance are considered. The nature of language and of symbols, the meaning of thinking, the human brain and nervous system, and other allied topics are also included.

HANDBOOK OF INDUSTRIAL RADIOLOGY, by Members of the Industrial Radiology Group of the Institute of Physics. Edited by J. A. Crowther. Second edition. Longmans, Green and Company, New York, N. Y.; Edward Arnold and Company, London, England, 1949. 218 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $4. The nine chapters contributed by experts, deal mainly with the production of the finished radiogram, the interpretation of which is dealt with only incidentally. Topics covered include physical principles, quantitative measurements, the response of photographic materials, X-ray protection, and actual radiographic techniques. There is a considerable bibliography of classified miscellaneous applications.

HEAT POWER FUNDAMENTALS. By C. M. Leonard and V. L. Maleev. Pitman Publishing Corporation, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 596 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.75. This book is written for use in a first course in heat-power engineering. The first part deals with steam power plant and contains basic theory of thermodynamics. The second part is devoted to a study of gas power plants, both of the reciprocating-engine and turbine types. The last part describes mechanical refrigeration. Tables of properties of steam and air are appended.

(The) HEAT PUMP, ITS PRACTICAL APPLICATION. By J. B. Pinkerton. Princes Press Ltd., 147 Victoria Street, Westminster, London, S.W.1, England, 1949. 257 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_4$ inches, cloth, 25s. Based on a series of articles in "Air Treatment Engineer," this book is written for the engineer who is concerned with the design installation, or maintenance of heat pump installations. Following the section on theory, practical applications are considered. The third and last section deals with the development of atomic energy as a fuel. A bibliography is included.

AN INTRODUCTION TO THE GAS TURBINE. By D. G. Shepherd. D. Van Nostrand Company, New York, N. Y., 1949. 387 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $5. Filling the gap between nontechnical descriptive matter and very specialized reports, this book provides an introduction to gas turbine theory and design. Following initial chapters on the basic physical and engineering concepts, the various components are described, and an outline of some design methods given. The remaining chapters discuss auxiliary equipment and control methods and provide illustrations of the practical use which is made of the constant-pressure gas turbine. Specialized calculations are dealt with in appendixes. Chapter bibliographies are included.

PRINCIPLES OF ELECTROPLATING AND ELECTROFORMING (Electrotyping). By W. Blum and G. B. Hogaboom. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 455 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. This book summarizes and digests, for engineers and chemists, the available knowledge of the theory and practice of electroplating. In this third edition, the analytic methods are grouped in one chapter instead of being distributed according to the specific baths. Metals are now discussed in groups according to the periodic system. Material on electrodeposition, on plastics and alloys is also included.

RADAR SYSTEMS AND COMPONENTS. By members of the Technical Staff of Bell Telephone Laboratories, with an introduction by M. J. Kelly. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England; 1949. 1042 pages, illustrations, diagrams, charts, tables, $99^1/_4$ by 6 inches, cloth, $7.50. The 15 papers contained in this volume were originally published in the *Bell System Technical Journal* and have been republished in this form because of the broad application of the work described to the new field of microwave transmission. The several papers deal in detail with various apparatus elements such as the magnetron oscillator, special switches, reflex oscillators, crystal rectifiers, radar antennas, cavity resonators, microwave radio receivers, and microwave radio testing equipment.

RADIO-FREQUENCY HEATING EQUIPMENT. By L. L. Langton. Pitman Publishing Corporation, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1949. 196 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75. Beginning with dielectrics and eddy-current fundamentals, this book deals with the design of equipment for the generation and transfer of radio-frequency power for heating

purposes. Applications of the techniques are dealt with broadly in two chapters. A simplified mathematical treatment is used throughout.

RECORDING AND REPRODUCTION OF SOUND. By O. Read. Howard W. Sams and Company, Indianapolis 1, Ind., 1949. 364 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $5. This book covers the essential requirements for a complete understanding of various aspects of sound and their relation to recording techniques and methods of reproduction. Theoretical considerations are fully explained and translated into practical descriptions, instructions, and advice. Proposed terminology and standards, a glossary, a bibliography of magnetic recording, and other useful information are also included.

REWINDING SMALL MOTORS. By D. H. Braymer and A. C. Roe. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1949. 422 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $4.50. A practical man's handbook on the winding of small d-c and a-c motors, this third edition includes and concentrates on the newer materials, methods, and processes. The detailed instructions for windings have been increased. Many new materials treated include synthetic resins, enameled wire, glass-insulated wire, silicon varnish, and combinations of these.

WELD DESIGN. By H. D. Churchill and J. B. Austin. Prentice-Hall, New York, N. Y., 1949. 216 pages, illustrations, diagrams, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, $6.65. This concise volume considers both the practical and theoretical aspects of welded machine-base design. Construction materials and methods of processing plates and structural shapes are treated in detail. Welding technique is not considered. The appendixes contain stress-design data and a bibliography of magazine articles and books.

RADIO-FREQUENCY HEATING. By L. Hartshorn. George Allen and Unwin Ltd., Ruskin House, 40 Museum Street, London, W. C. 1, England, 1949. 237 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, 21s. A systematic account is given of the principles and applications of both the induction heating of metals and the dielectric heating of nonmetals. For the processes considered in the book only electronic-tube generators are extensively used, and only these are considered in detail. Data relevant to processes for a wide range of materials are included.

NETWORKS, LINES, AND FIELDS. By J. D. Ryder. Prentice-Hall, Inc., New York, N. Y., 1949, 462 pages, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, $7.35. In this text the author discusses the subjects of networks, resonance, and wave filters in order to develop in the undergraduate student a familiarity with network theory. The fundamental network definitions are applied first to lumped networks and then to distributed constant circuits. The rationalized MKS system of units is used throughout, and differential notation rather than notation of vector analysis is used.

RADIO TECHNOLOGY, TELEGRAPHY, TELEPHONY, TELEVISION, TRANSCRIPTION, FACSIMILE. By E. J. Vogt. Pitman Publishing Corporation, New York, N. Y., London, England, 1949. 556 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Of interest to the practical radio engineer, this comprehensive handbook of basic information bridges the gap between very elementary and specialized studies. It contains the necessary material for a complete understanding of radio phenomena. The illustrative problems and questions at the end of each chapter are taken from the "Federal Communications Commission Study Guide for Commercial Radio Operator Examinations." The necessary mathematics is summarized in an early chapter.

IONIZATION CHAMBERS AND COUNTERS: EXPERIMENTAL TECHNIQUES. By B. B. Rossi and H. H. Staub. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 243 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $2.25. This volume is one of a series which records the research work done under the Manhattan Project and the Atomic Energy Commission. Part 1 discusses the general physical principles underlying the operation of ionization chambers and counters, with special emphasis on modern detection techniques. Part 2 presents detailed discussions of a number of detectors used at the Los Alamos Laboratory for the study of different kinds of radiations.

JET-PROPELLED AIRCRAFT POWER PLANTS. By J. P. Enames. Pacific Aero Tech., San Francisco, Calif., 1949. 121 pages, illustrations, diagrams, charts, tables, 8 by $5^1/_2$ inches, fabrikoid, $3. Following a brief review of fundamentals, compressorless jet, turbojet, propjet, and pocketjet power plants are treated in a concise manner. Maintenance problems are discussed, and construction materials are described. A glossary of terms is included.

METALS REFERENCE BOOK. By C. J. Smithells. Interscience Publishers, New York, N. Y.; Butterworths Scientific Publications, London, England, 1949. 735 pages, diagrams, charts, tables, $9^3/_4$ by $6^1/_4$ inches, linen, $13.50. Of use to scientists and engineers, this comprehensive reference book is a summary of a wide range of physical, mechanical, and electrical data relating to metallurgy and metal physics. For the most part, data are presented in the form of tables and diagrams, but short monographs are used where the information could not otherwise be adequately presented.

MODERN OSCILLOSCOPES AND THEIR USES. By J. H. Ruiter, Jr. Murray Hill Books, New York, N. Y.; Toronto, Ontario, Canada, 1949. 326 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Written for electronics students and engineers who use oscilloscopes in their work, this book deals with the principles, components, and uses of oscilloscopes. The operation of the oscilloscope is explained with detailed information on each element. Numerous step-by-step procedures are included, as well as a glossary of terms, descriptions of auxiliary equipment, and techniques for photographing patterns from the screen of the cathode-ray tube.

NONLINEAR PROBLEMS IN MECHANICS OF CONTINUA. (Proceedings of Symposia in Applied Mathematics, volume 1.) Published by the American Mathematical Society, 531 West 116th Street, New York, N. Y., 1949. 219 pages, diagrams, charts, tables, $10^1/_4$ by 7 inches, cloth, $5.25. This volume contains papers presented at the First Symposium on Applied Mathematics, 1947, of the American Mathematical Society. The papers have been subdivided into two groups: one concerned with the field of hydro- and aerodynamics; the other including results in electricity and plasticity. A few of the papers presented at the symposium were published elsewhere, and of these comprehensive abstracts are given.

TECHNICAL SKETCHING AND VISUALIZATION FOR ENGINEERS. By H. H. Katz. Macmillan Company, New York, N. Y., 1949. 163 pages, illustrations, diagrams, charts, $10^1/_4$ by $7^1/_2$ inches, cloth, $5. This book is a text and reference on the applications and techniques of technical sketching. Initial chapters describe the various types of sketches. Following chapters give thorough, step-by-step instruction in drawing. A final chapter describes various nongraphical means of visualization used in engineering, such as cutouts, overlays, and clay models.

TRANSFORMATION CALCULUS AND ELECTRICAL TRANSIENTS. By S. Goldman. Prentice-Hall, New York, N. Y., 1949. 439 pages, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $8.35. Of interest to development and research workers in electrical engineering, this book develops the methods of the Laplace transformation and its inverse for the solution of problems in electric circuit transients. It emphasizes questions of physical interpretation and gives the solution of many important examples. It presents a comprehensive and systematic treatment of the subject of transients in linear networks. Nonlinear networks are not treated.

VERSO L'ELETTROTECNICA MODERNA. By G. Giorgi. Libreria Editrice Politecnica, Cesare Tamburini, Milan, Italy, 1949. 355 pages, diagrams, charts, tables, $9^3/_4$ by $6^3/_4$ inches, paper, 1,400 lire. This historical survey of the development of electrical theory, apparatus, and technique covers a considerable field, with special attention to systems of units, magnetism, and electromagnetism, and certain special aspects such as permanent magnet material, the starting and interruption of the electric current, and so forth. There is brief discussion of the subject of priority of discovery of various electric and electromagnetic devices by Italians or others. Bibliographies accompany the major sections of the book.

ABRISS DER DAUERMAGNETKUNDE. By J. Fischer. Springer-Verlag, Berlin, Göttingen, Heidelberg, Germany, 1949. 240 pages, illustrations, diagrams, charts, tables $10^1/_4$ by 7 inches, paper, 36 DM; linen-bound, 39 DM. This book is a quantitative description of magnetic fields, states, processes, and properties which are important in the employment of permanent magnets. It contains formulas, numerical values, a discussion of the technology of permanent magnet materials, and a consideration of the microphysical theory of ferromagnetism.

ALTERNATING CURRENT MACHINERY. By L. V. Bewley. Macmillan Company, New York, N. Y., 1949. 376 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_4$ inches, cloth, $5.25. Intended both as a text and reference source, this book presents a general method of analysis applied to the more important kinds of a-c machinery. Transformers, polyphase and single-phase induction motors, a-c commutators, synchronous generators and motors, and synchronous converters are discussed in detail and in relation to general equations of voltage and armature reactions. There are many essential departures from traditional treatment.

ELEMENTS OF PATENT LAW. By F. H. Rhodes. Cornell University Press, Ithaca, N. Y., 1949. 189 pages, $8^3/_4$ by $5^3/_4$ inches, cloth, $2.75. In simple, nonlegal language, this book supplies the answers to many points about patents for inventions with which the inventor should be informed. Design patents are not considered. In addition to a discussion of the whys and wherefores of patent law, citations from a selected list of court decisions, with summaries of the significant circumstances of the individual cases, are included.

FUNDAMENTALS OF POWER PLANT ENGINEERING. By G. E. Remp. National Press, Millbrae, Calif., 1949. 347 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $6.50. This book is designed both as a text for a course in power engineering and as a reference work for engineers. Although the principal portion is devoted to steam power plants, there are also chapters on Diesel-electric, hydroelectric, and gas-turbine power plants. Special emphasis is placed on power plant economics, the estimation of equipment performance, and heat transfer calculations.

FUNDAMENTALS OF VACUUM TUBES. By A. V. Eastman. Third edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 644 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.50. Following the general pattern of previous editions, this book discusses the principal types of vacuum tubes and the laws governing their operation, with engineering analyses of the more important applications. New material is included on video amplifiers, cathode-follower amplifiers, resistance-capacitance oscillators, grounded-grid amplifiers, pulse modulation and demodulation. New photographs, figures, and problems are also included.

INDUSTRIAL ELECTRONICS. By A. W. Kramer. Pitman Publishing Corporation, New York, N. Y., and London, England, 1949. 311 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. More than half of this practical book is devoted to a consideration of basic principles. These principles are dealt with more or less chronologically, thus progressing logically from the simpler tube types to the more complex. Following this groundwork, applications are considered in terms of classified groups. The book is intended for those with a knowledge of general physics and engineering but with little training in electronics. The step-by-step explanations are achieved without the use of mathematics.

METAL RECTIFIERS (Monographs on the Physics and Chemistry of Materials). By H. K. Henisch. Oxford University Press, New York, N. Y.; The Clarendon Press, Oxford, England, 1949. 155 pages, charts, diagrams, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75. This book deals with the theory and practice of dry rectifiers, especially those aspects of the subject which are parts of physics rather than of engineering. It is written for practical workers in this field who wish to familiarize themselves with recent advances in the understanding of the subject. Notes are given on future rectifier development, and an extensive chronological bibliography is included.

DAS NATÜRLICHE MASSYSTEM. By G. Oberdorfer. Springer-Verlag, Vienna, Austria, 1949. 34 pages, tables, 8 by $5^3/_4$ inches, paper $0.84. This pamphlet is a critical investigation of the basis for the formulation of a universal measuring system for physics and technology. The "natural" (MKS) system, based on the meter-kilogram-second, is discussed in detail, and other systems are mentioned briefly. A table is included which lists the comparative values and formulas in the various systems of units.

FIVE-FIGURE TABLES OF MATHEMATICAL FUNCTIONS. By J. B. Dale. Edward Arnold and Company, London, England; Longmans, Green, and Company, New York, N. Y. Second edition, 1949. 121 pages, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $1.50. This small book provides tables of logarithms, powers of numbers, trigonometric, elliptic, and other transcendental functions. Decimal equivalents, conversion of time and angular measure, and a compilation of special numbers used in calculations are included. The 5-figure entry has been used as the most effective for all-around practical use.

HEAT TRANSFER, Volume I. By M. Jakob. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 758 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, $12. Useful both as a treatise for research workers and as a textbook, this volume shows the development of ideas which have led to the present knowledge of the subject of heat transfer. There is a parallel treatment of conduction, convection, and radiation. The first part of the book contains the basic equations; the second part deals with the pertinent properties of matter; succeeding sections provide the solutions and applications of the equations to various types of heat flow. An extensive reference list is included.

INTRODUCTION TO THE THEORY OF FOURIER'S SERIES AND INTEGRALS. By H. S. Carrslaw. Third edition, revised and enlarged. Dover Publications, Inc., New York, N. Y., 1949. 368 pages, diagrams, charts, tables, $8^1/_4$ by $5^1/_2$ inches, cloth, $3.95. This book is a reprinting of a standard mathematical treatise which has been out of print for some three years. There is a historical introduction as well as a detailed treatment of the fundamentals of mathematical physics.

INVENTION AND INNOVATION IN THE RADIO INDUSTRY. By W. R. Maclaurin, with technical assistance of R. J. Harman, and foreword by K. T. Compton. The Macmillan Company, New York, N. Y., 1949. 304 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $6. Written almost entirely in nontechnical terms, this book traces the technical and economic development of radio from its scientific origins to the present, including frequency modulation and television. It describes technological advances which have shaped the industry, discusses key inventors and the role of companies in introducing improvements. The question of the patent system is dealt with in detail.

COMMUNICATION CIRCUITS. By L. A. Ware and H. R. Reed. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 403 pages, charts, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $5. Intended as a text for students of communication engineering, this book presents the basic principles of communication transmission lines and their associated networks. The frequency range covered includes voice frequencies through the ultrahigh frequencies. In this third edition, the rational MKS system of units is used, the chapter on transmission-line parameters is revised, and new problems and additional discussion added.

DIMENSIONS IN ENGINEERING THEORY. By G. W. Stubbings. Crosby Lockwood and Son, Ltd., London, England, 1948. 107 pages, tables, $7^1/_2$ by 5 inches, cloth, 7s.6d. Beginning with a discussion of fundamental units, this elementary work continues with an explanation of the basic principles of dimensions, and the applications of dimensional analysis are dealt with and illustrated. Separate chapters are devoted to the dimensions of the dynamics of rotation of thermal quantities, and of electrical quantities.

ELECTRIC CIRCUITS AND MACHINES. By B. L. Robertson and L. J. Black. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England, 1949. 434 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, leather, $5. This book presents the basic concepts that underlie electric circuits, machines, and electronics, and points the way to use of these principles in practical problems. Emphasis is on the a-c circuit, particularly single phase. Problems are included at the end of each chapter and form an integral part of the text.

EXTRAPOLATION, INTERPOLATION, AND SMOOTHING OF STATIONARY TIME SERIES WITH ENGINEERING APPLICATIONS. By N. Wiener, published jointly by The Technology Press of the Massachusetts Institute of Technology and John Wiley and Sons, Inc., New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 163 pages, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $4. Of interest to communication engineers and statisticians, this book represents the first stage of the statistical point of view in communication engineering. It contains the specific problems of the design of linear predictors and linear wave filters. The main ideas of the text are developed in a simpler mathematical form in the appendix.

FUNDAMENTALS OF ELECTRO-MAGNETISM. By E. G. Cullwick. Cambridge University Press, American Branch, 51 Madison Avenue, New York 10, N. Y., 1949. 327 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $4. Restating the fundamentals of electricity and magnetism, this book presents the elementary theories in a way which is consistent with the viewpoint of modern physics. The whole question of the meaning of the physical concepts is discussed. All theory is given in a form which can be used either with orthodox units or the new MKS practical units.

HANDBOOK OF PATENTS. By H. A. Toulmin, Jr., D. Van Nostrand Company., Toronto, Ontario, Canada; New York, N. Y.; London, England, 1949. 800 pages, illustrations, diagrams, maps, $9^1/_4$ by 6 inches, cloth, $9. Written for the businessman, inventor, engineer, and executive, this handbook deals with the essentials and philosophy of patent law. It furnishes an understanding of the relationship of the patent law to manufacturing, research, and engineering. Each step in preparing and safeguarding a patent is discussed. There are also chapters on foreign patents and the treaties and conventions dealing with patents to which the United States is a party.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Tables of Sines and Cosines to 15 Decimal Places at Hundredths of a Degree. National Bureau of Standards Applied Mathematics Series 5. 95 pages. Priced at 40 cents. Available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Bibliographies on Electric Equipment. Both "Electric Motors and Generators" and "Electrical Appliances" list books and periodicals. Each is free on request to the Department of Commerce, 42 Broadway, New York 4, N. Y.

Census of Manufacturers for 1947. The following four booklets give detailed statistics on employees, employers, materials, expenditures, and income for the electrical manufacturing industry in 1947. Prepared by the Bureau of the Census, Department of Commerce, they are: "Electrical Industrial Apparatus," MC36A; "Electrical Appliances and Lamps, Insulated Wire and Cable, and Engine Electrical Equipment," MC36B; "Communication Equipment and Related Products," MC36C; and "Miscellaneous Electrical Products," MC36D (includes storage batteries, primary batteries, and X-ray and therapeutic apparatus). MC36A is priced at 15 cents; the other three sell for 10 cents per copy. Remit orders to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Electrical Communication Index. A 162-page cumulative index covering the first 25 volumes (1922–48) of *Electrical Communication*, technical journal of the International Telephone and Telegraph Corporation, 67 Broad Street, New York 4, N. Y., which may be obtained for one dollar from that organization.

Bibliography on Precision Investment Casting by the Lost Wax Process. Engineering Societies Library Bibliography Number 3. Contains 111 references covering theory, design problems, industrial applications, production methods, and historical background. The 14-page booklet is available at $2.50 per copy from the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y.

Establishment and Maintenance of the Electrical Units, by F. B. Silsbee. Circular C475. Describes new system of electrical measurements using "absolute" units adopted by the International Conference of Weights and Measures and officially instituted January 1, 1948. 38 pages. Priced at 25 cents. Available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Guide to Use of Cold-Cathode Fluorescent Lighting. Included in this 8-page booklet are charts giving photometric data on standard lamps and sections on installation of cold-cathode tubes. The guide can be obtained from the Fluorescent Lighting Association, 501 Fifth Avenue, New York 17, N. Y.

Spectrophotometry, Circular 484, by Kasson S. Gibson, National Bureau of Standards. Instruments for use in the ultraviolet, visible, and near-infrared spectral regions are considered. Photographic, visual, and photoelectric methods are given. 48 pages. Available at 25 cents per copy from the United States Government Printing Office, Washington 25, D. C.

National Electrical Code. Gives complete code including 1949 revision, official interpretations, and examples. Provides for safeguarding of persons and buildings and their contents against electrical hazards. Is a 6- by 9-inch cloth-bound volume containing 420 pages. Available at three dollars from the National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass.

Outline for Pension Planning. A group of 12 articles offering a practical guide to problems involved in setting up a company pension plan. Available in a 16-page booklet priced at 50 cents per copy from The Journal of Commerce, 63 Park Row, New York 15, N. Y.

Cathode Heater Compensation as Applied to Degenerative Voltage-Stabilized D-C Power Supplies, RP2027, by Robert C. Ellenwood and Howard E. Sorrows, five pages, ten cents. Discusses a new method of compensating a degenerative-type voltage stabilizer that simplifies the design of precision-stabilized d-c power supplies. Available from the Superintendent of Documents, United States Printing Office, Washington 25, D. C.

Annual Report, Armour Research Foundation, Illinois Institute of Technology. Illustrated in color, this 40-page booklet describes the foundation's research accomplishments during 1949. Available from the foundation at Technology Center, Chicago 16, Ill.

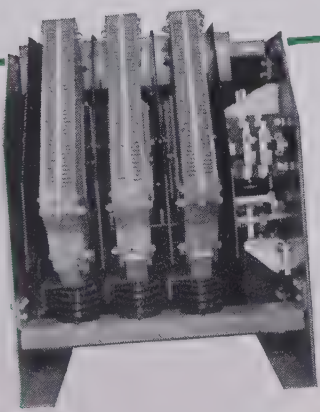
NOW! 5000V in 34"

NEW
SMALLER G-E LIMITAMP AIR-BREAK CONTROLLER

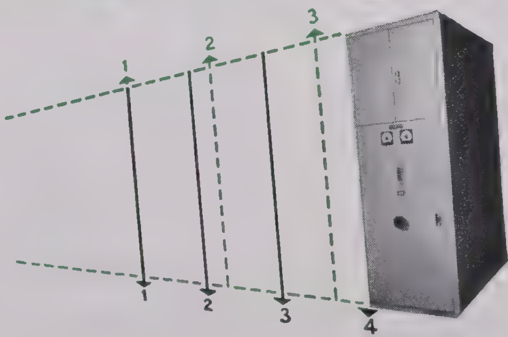
Only 34 inches wide—including enclosure—as contrasted to the previous 52, yet capable of controlling 840 more volts—that's modern design exemplified in this new high-voltage control for motors up to 1250 horsepower.

G-E developed EJ-2 fuses, providing quiet, fast-acting short-circuit protection are enclosed in a compartmented steel cabinet with the new, low-inertia air-break contactor. All the control you need for motors (even those on rapid duty cycle) is engineered, assembled, and tested in our factories to save you layout, installation, operation, and maintenance costs.

Write for more information in Bulletin GEA-5409. This includes descriptions of oil-immersed Limitamp control, reduced-voltage, two-speed, and reversing forms as well as the new full-voltage air-break controller.
Apparatus Dept., General Electric Co., Schenectady 5, N. Y.



MORE VOLTAGE New air-break design increases the maximum rating from 4160 to 5000 volts.



LESS SPACE Width of cabinet is reduced, so now, four air-break controllers can occupy the space formerly taken by three.

GENERAL ELECTRIC

730-12

INDUSTRIAL NOTES . . . .

Five Vice-Presidents Elected by RCA. The Radio Corporation of America has announced the election of five Vice-Presidents, all associated with the RCA Victor Division. The new officers are Henry G. Baker, Vice-President and General Manager of the Home Instrument Department; Richard T. Orth, Vice-President and General Manager of the Tube Department; John S. Carter, Vice-President and Director of the Finance Department; Paul A. Barkmeier, Vice President and General Manager of the Record Department; and Harold R. Maag, Vice-President and Western Manager of the RCA Victor Division.

United States Steel Appointments. Harvey B. Jordan, Vice-President in charge of operations of American Steel and Wire Company at Cleveland, Ohio, since 1939, has been elected President of this United States Steel Subsidiary. Mr. Jordan succeeds Clifford F. Hood, who has been elected President of Carnegie-Illinois Steel Corporation, the principal steel-producing subsidiary of United States Steel. In addition, Charles R. Cox has resigned as President of Carnegie-Illinois Steel Corporation to become President of Kennecott Copper Corporation. Mr. Cox succeeds the late E. T. Stannard, who recently died in an airplane accident in Canada. Another appointment is that of James E. Lose, Vice-President in charge of operations, Carnegie-Illinois Steel Corporation, to the position of Executive Vice-President.

Kodak Subsidiary Becomes Kodak Division. Distillation Products, Inc., the wholly owned subsidiary of Eastman Kodak Company, has been dissolved as a separate corporation to become a division of the parent company. The new division will be known as Distillation Products Industries, retaining the initials DPI, widely used in its advertising. The division will continue the same manufacturing and selling activities with no intended change in personnel.

G-E News. The General Electric Company has announced that the manufacture of 15,000-kw turbine generator sets has been transferred from Schenectady to the G-E River Works in Lynn, Mass. The transfer was made to reduce shipment time on such equipments, which have been previously sold on a price-at-time-of-shipment basis.

The company has also announced the retirement of Donald H. Wyre, Manager of the Allegheny Sales District of General Electric's Lamp Department, and the appointment of Warren P. Thayer as his successor. N. H. Boynton, sales consultant in the administrative staff of the company's Lamp Department at Nela Park, has also retired, after 40 years' service.

E. F. Davies Dies. Edgar F. Davies, 68, who retired in 1946 as Manager of the System Operation Department of the Consolidated Edison Company of New York, Inc., died in St. Petersburg, Fla., where he had gone recently to live.

Kennametal, Inc., Appointment. Kennametal, Inc., Latrobe, Pa., has appointed John McVeigh as Special Development Engineer to augment its technical research staff engaged in extending the application of their new heat resistant material, Kentanium.

Fairchild News. Lawrence B. Richardson has been named Director of Research of the Fairchild Engine and Airplane Corp. Formerly President of the corporation, Mr. Richardson remained as a consultant to the new management following the proxy contest last July, which resulted in the election of a new Board of Directors.

Fairchild has also announced that the name of the Pilotless Planes Division of the corporation, located at Farmingdale, N. Y., has been changed to Fairchild Guided Missiles Division.

Electronic Computer Company Formed. Due to the widening industrial appreciation of the use of electronic digital computers, a new company has been formed, specializing in these instruments—the Electronic Computer Corporation, with offices and plant at 265 Butler Street, Brooklyn, N. Y. The company is headed by Dr. Samuel Lubkin, formerly consultant to the National Bureau of Standards on mathematical, logical and engineering phases of electronic digital computers.

Burroughs Opens New Testing Lab. The Burroughs Adding Machine Company has announced completion of a new copper insulated test facility in its Detroit engineering laboratories, to be used for the scientific testing of electrical equipment for interference with radio and television reception.

NEW PRODUCTS . .

Nuclear Energy and Flame Detector Devices. The Brown Instruments Division of the Minneapolis-Honeywell Regulator Company has announced two new instruments—the first, a nuclear energy detector capable of measuring to millionths of a millionth of an ampere. Called the Brown electrometer, the instrument was designed to measure and record very small currents like those developed in an ionization chamber as a result of radiation. The same company has also developed a foolproof flame detector which eliminates previous limitations in electronic safeguards for processes where oil- or gas-fired burners are used. The device, known as the Protectoglo, operates on flame rectification principles, and applies alternating current to either a flame-electrode immersed in the flame or to a photocell

(*Continued on page 20A*)

Simplified STUDY OF LIGHTNING

➡ Lightning—nature's violent electrical impulse—places great strain on even the most perfectly devised high-voltage insulation.

Therefore, testing the effects of insulation breakdown is of vital importance in the manufacture of high-voltage transformers, lightning arresters, and other equipment designed to withstand transient signals of excessive amplitude.

And here's the good news: The design of the completely new and specialized Du Mont Type 293 Oscillograph indicates that these effects *can be measured with a hot-cathode, sealed-off cathode-ray tube.*

The development of the Du Mont Type 5RP-A Cathode-ray Tube has made possible the visual and photographic observation of writing rates involved in surge testing. For calibration of a typical impulse test-wave, a d-c voltmeter provides continuous, direct-reading accuracy within 1% of full scale. Time calibrations may be made at intervals of 0.05, 0.1, 1.0, 50 or 250 microseconds, with 0.2% accuracy.

Adequate attenuators are provided for input signals as high as 2500 volts on both the horizontal and vertical axes of the Type 293 Oscillograph, where one quantity is to be plotted as a function of another. Driven, undelayed sweeps are also provided for deflection on the horizontal axis with fixed durations of 0.5, 2.5, 10, 50, 250 or 1000 microseconds. The sweep voltage is logarithmic, assuring good definition of the early part of the steep wavefront. Permanent records of the test surge may be made with a detachable 35 mm camera, using an f/1.5 lens, provided with the Type 293 Oscillograph.

➡ A complete description of this new and important advancement in the field of surge testing may be obtained by writing to the Instrument Division, Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

DUMONT *for Oscillography*

ALLEN B. DUMONT LABORATORIES, INC., *INSTRUMENT DIVISION*, 1000 MAIN AVENUE, CLIFTON, NEW JERSEY

(*Continued from page 16A*)

sighted at the flame. It can be interlocked with any needed combination of control devices and accessory equipment. Further information on these instruments is available from the company at 4535 Wayne Avenue, Philadelphia 44, Pa., upon written request.

Cornell-Dubilier Developments. The Cornell-Dubilier Electric Corporation, South Plainfield, N. J., has announced a new line of direct current to alternating current converters, the Powercon line. Designed for use with radio or television equipment, the converters are filtered for clear reception, and are capable of starting under full load without the necessity of starting the converter first and then applying the load. The most frequent use of these units is to create 110-volt 60-cycle alternating current from battery or other d-c sources to permit the operation of standard radio or television receivers, amplifiers, record-players, or small electric appliances in locations where commerical alternating current is not available.

Another development at the company is the Tele-rotor, which has the ability to take a great amount of wind stress and to carry television and amateur antenna arrays without overloading the motor (up to 300 pounds). The motor is weather-sealed, lubricated for life, is instantly reversible, and is operated by directional push buttons. Any further details on these developments may be had by writing to the company.

Sylvania Developments. The Sylvania Electric Company has announced the following new developments: 1. A 300-watt weatherproof incandescent reflector lamp suitable for any outdoor lighting applications, called the *R-40* lamp. The lamp, five inches in diameter, is enclosed in a heat-resistant glass bulb which absorbs the thermal shocks caused by rain, snow, insects, oil, and other elements. The reflector flood light has a mogul screw base and operates on 115, 120, and 125 volts. 2. Three electron tubes with service life up to 10,000 hours, and specially designed mounts to withstand shock and vibration. Structural specifications include ability to resist impact shocks of 100 G for prolonged periods, 500 G for short periods, and $2^1/_2$ G during continuous vibration at 20 cycles per second, while being operated at maximum rated voltages. The three types include *5691*, a high-mu twin triode recommended for voltage amplifier use and supplied with series-unit heaters; *5692*, a medium-mu twin triode with series-unit heaters suitable for balanced d-c amplifier, multivibrator, blocking oscillator, and resistance-coupled amplifier applications; and *5693*, a sharp cut-off pentode designed particularly for high-gain resistance coupler amplifier service. The *5693* may be operated with number one grid resistance values up to 40 megohms. Any additional details on these products may be obtained by writing to Sylvania Electric Products, Inc., 500 Fifth Avenue, New York 17, N. Y.

(*Continued on page 26A*)

A SPECTACULAR DEVELOPMENT

in Allen-Bradley Thermal Overload Relays makes it possible to provide your motors with this TWO WAY PROTECTION

1. Starting and locked rotor protection for motors with widely different characteristics.
2. Running overcurrent protection to prevent motor from operating at damaging temperatures.

Now you can match your overload protection for motors under starting and locked rotor conditions as well as under running conditions. Allen-Bradley starters now have interchangeable overload relay spindles to provide various tripping characteristics. The proper spindle gives your motor locked rotor and starting protection. The proper heater element gives running protection. Unnecessary shutdowns will then be eliminated.

1 Interchangeable Relay Spindles

for Starting Cycle Protection

GREEN SPINDLE—For motors with low locked rotor current or short allowable locked rotor time.

RED SPINDLE—For motors with normal allowable locked rotor time and normal starting time.

TAN SPINDLE—For motors with normal allowable locked rotor time and long starting time. Ideal for flywheel and other high inertia loads.

Bulletin 815 Resisto Therm Overload Relay . . . the type used on most Allen-Bradley motor starters.

2 Interchangeable Heater Elements

for Running Cycle Protection

These heater elements, which carry the main motor current, are selected to match the rating of the motor. Allen-Bradley supplies 61 heater sizes to provide adequate coverage of all motor ratings.

These heaters, when used in conjunction with the three types of spindles illustrated at left, provide 183 combinations to match the characteristics of your motors.

That's why Allen-Bradley motor starters provide full motor protection.

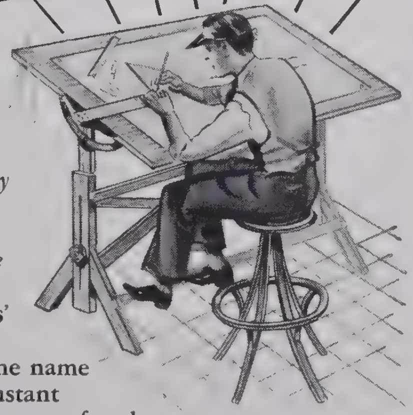
ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

A-B Quality

2-50-MR

(OVER)

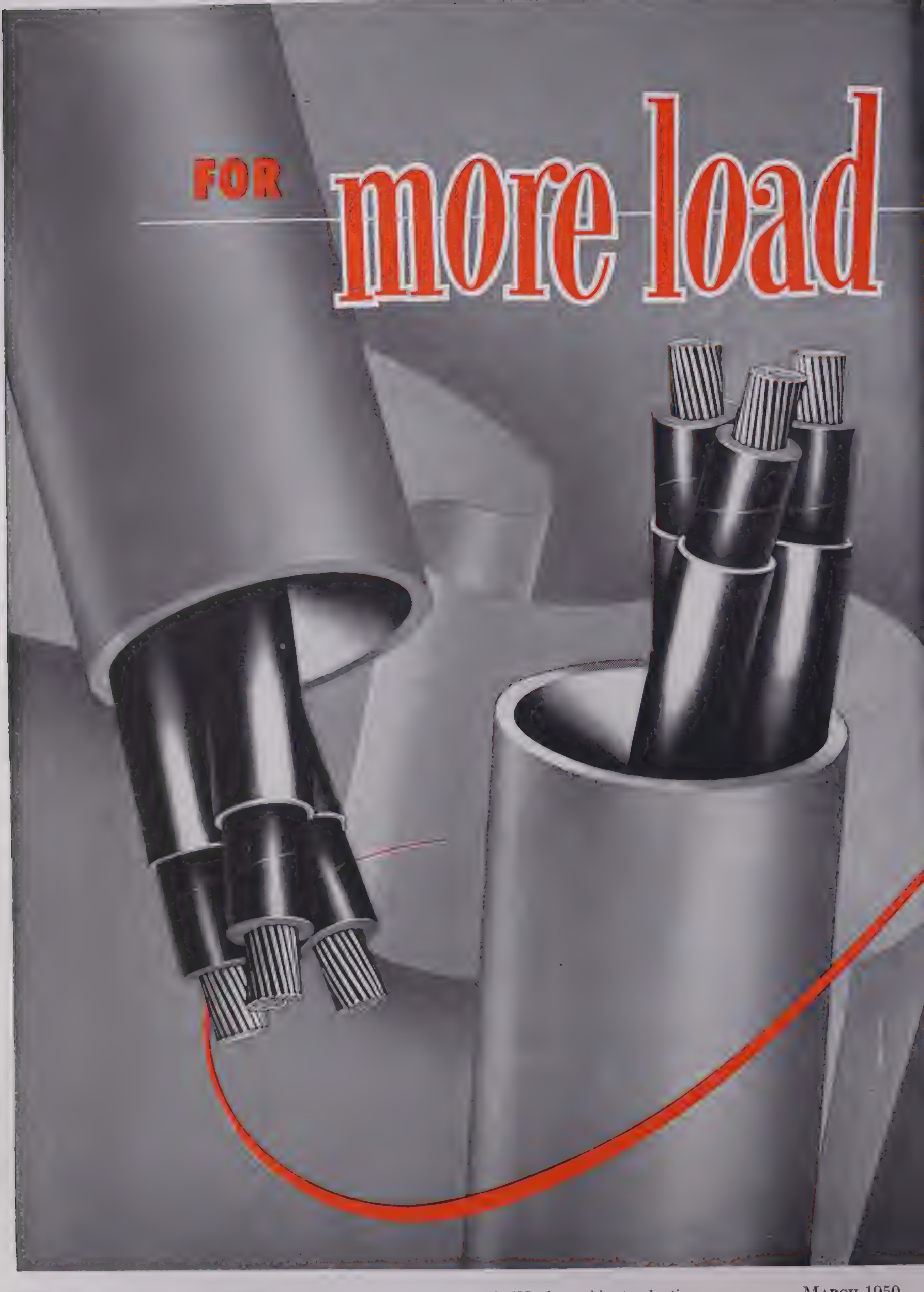
"Built-in" OPERATING ASSURANCE



Nowhere does WESTON *dependability* and *value* pay bigger returns than on the panels or controls of electrical equipment. By consistently *telling the truth,* they help assure efficient performance of the equipment in users' hands . . . where *so much* depends on instrument performance. Moreover, the name WESTON on a panel instrument gains instant recognition . . . helps build buyer acceptance for the products on which they are installed. Available in types, sizes, ranges and styles for all needs. Ask your nearest WESTON representative for all the facts, or write for bulletin A-7-B. WESTON Electrical Instrument Corporation, 664 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON
Panel Instruments

Albany • Atlanta • Boston • Buffalo • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Jacksonville • Knoxville Little Rock • Los Angeles • Meriden • Minneapolis • Newark • New Orleans • New York • Orlando • Philadelphia • Phoenix • Pittsburgh • Rochester San Francisco • Seattle • St. Louis • Syracuse • Tulsa • Washington, D. C. • In Canada, Northern Electric Company, Ltd., Powerlite Devices, Ltd.


FOR
more load

(Continued from page 20A)

Air Analyzing Instrument. The Leeds and Northrup Company has developed a new automatic analyzing instrument, the Thomas Autometer, which continuously records actual concentration of sulfur dioxide in parts per million, as well as average concentration integrated over a half-hour period; automatically checks its "zero reading" every 30 minutes; and marks off each cubic foot of air sampled. Usual range of the equipment is zero to five parts SO_2 per million. The Autometer makes use of electrolytic conductivity as a means of measurement. For further details, write to Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.

Plug-In Multi-Breaker Load Centers. Plug-in multi-breaker load centers for lighting and appliance circuits have been announced by the Square D Company, Inc., Switch and Panel Division, 6060 Rivard, Detroit 11, Mich. The plug-in feature makes it possible to conveniently add or change circuits as conditions require, thus minimizing wiring and installation time. The units are available in ratings of 15, 20, 30, 40, and 50 amperes, 120/240 volts alternating current. All Square D multi-breakers are of thermal (coilless) magnetic construction—the thermal element deflects in proportion to temperature of wire insulation resulting from both air and losses within the conductor; the magnetic element responds instantly to heavy overloads or short circuits, thus assuring complete protection. Further information is available from the company.

Marine-Shaft Horsepower-Hour Meter. General Electric's Special Products Division has developed a new electric instrument which measures the horsepower transmitted by the propeller shaft of a ship. Called a "marine-shaft horsepower-hour meter," the device gives instantaneous horsepower readings and horsepower totals over a given time interval. Resultant readings indicate the ship's operating efficiency. The instrument is expected to prove valuable in comparing fuel consumption with horsepower output under varying conditions, in checking performance of propulsion equipment over a wide range of speed, comparing output of power plant for similar trips and distances, studying fluctuations in horsepower output while speed remains constant, checking efficiencies of boilers and other equipment, and proving ships' performances during builder's trials. The meter operates on the principle that horsepower is the product of speed, torque, and a constant. Equipment consists of speed measuring apparatus, torque measuring electric gauge assembly, and a metering unit. Shaft speed is measured by use of a small a-c generator geared directly to the drive shaft so that the voltage generated is always an indication of the propeller shaft speed. Torque is measured by determining the elastic twist of the propeller shaft between two rings clamped to the shaft. Accuracy of the device is within plus or minus two per cent of shaft full horsepower rating.

(Continued on page 32A)

Give your transmission lines the sure and permanent protection that Copperweld Overhead Ground Wires afford. Every wire in the strand is permanently protected against corrosion by a thick covering of copper inseparably molten-welded to a tough alloy steel core. This insures rugged strength that is permanent—permits stringing with small sags—and provides ample mid-span clearance.

Thousands of important transmission lines, all over the world, are using Copperweld Overhead Ground Wires to insure dependable performance. You, too, can benefit by installing "Copperweld."

COPPERWELD STEEL COMPANY ***GLASSPORT, PA.***

Sales Offices in Principal Cities

Copperweld

TRADE MARK

NON-RUSTING

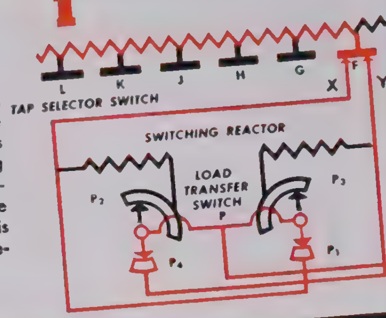
OVERHEAD GROUND WIRES

NEW PRINCIPLE OF REACTOR SWITCHING FEATURED ON MOLONEY

SCHEMATIC DIAGRAMS showing sequence of switching operations and how Switching Reactor loss is eliminated in all operating positions on 1¼% step voltage regulating apparatus and in half of the positions on ⅝% step voltage regulating apparatus. Colored lines indicate paths of current.

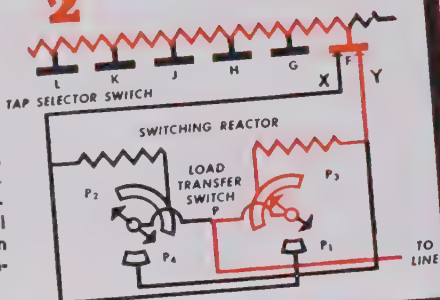
1

Switch positions for Load Tap Changer Operating Position No. 1 on either ⅝% or 1¼% step voltage regulating apparatus (assuming Reversing Switch is in Buck position). A 10% voltage buck is provided in this position. Note that reactor is by-passed.



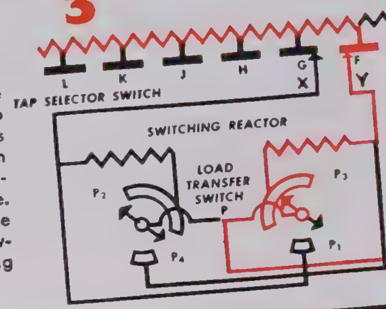
2

Assuming there has been an increase in load and the line voltage decreases, the Automatic Control, after a time delay, actuates the driving motor. The motor drive mechanism rotates the Load Transfer Switch 45° counter-clockwise, shunting all of the current through one half of the Switching Reactor.



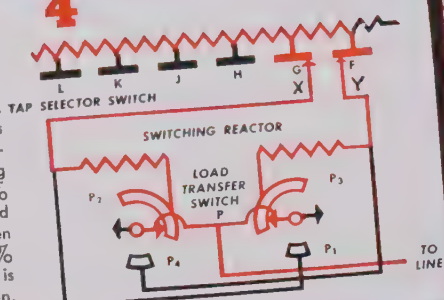
3

While the Load Transfer Switch remains in the position shown in Fig. 2, the motor drive mechanism continues to operate and rotates the Tap Selector Switch to the bridging position illustrated above. No arcing takes place since no current is flowing through moving contact X.



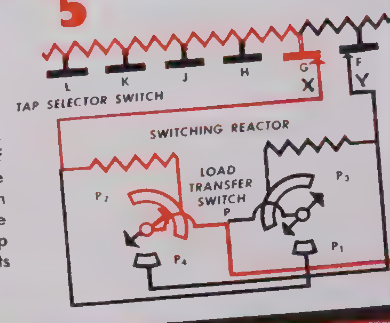
4

Load Transfer Switch rotates 45° counter-clockwise causing current to flow through both halves of reactor. Load Tap Changer is now in bridging position which is Operating Position No. 2 on ⅝% step apparatus and tap change has been completed. On 1¼% step apparatus this is a transitory position.



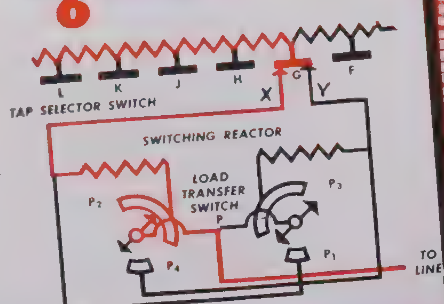
5

On 1¼% step apparatus the motor drive continues to operate and rotates the Load Transfer Switch 45° counter-clockwise, again shunting all of the current through one half of the reactor in preparation for the movement of the Tap Selector Switch to its next position.



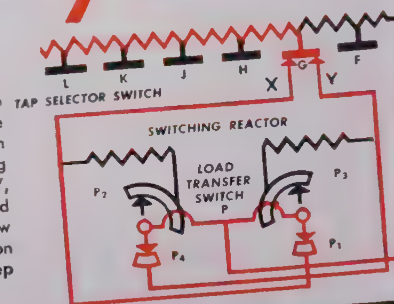
6

With no current flowing through moving contactor Y, the Tap Selector Switch now moves to the next position with X and Y on stationary contact G.



7

Next, the Load Transfer Switch rotates 45° counter-clockwise to complete the tap change. There is no reactor loss since the current flows through parallel by-passing circuits X, P_1, P and Y, P_4, P to the line. Load Tap Changer is now in Operating Position No. 2 on 1¼% step apparatus.



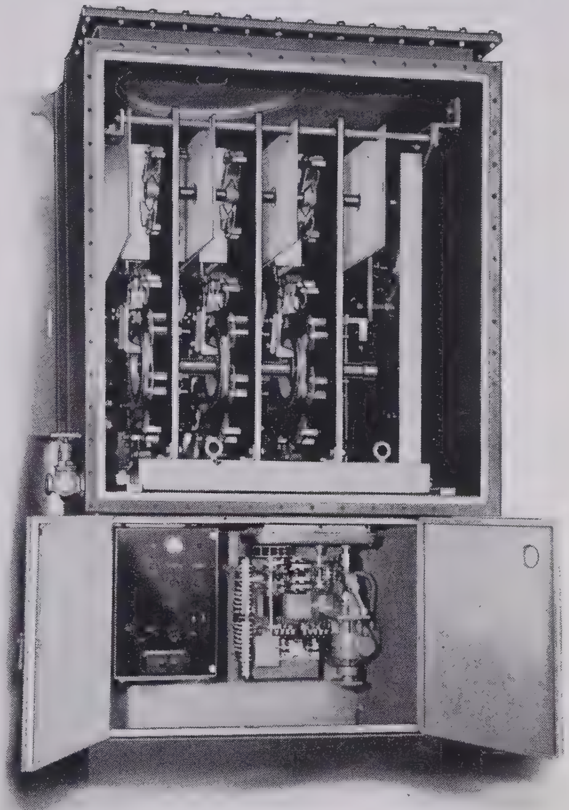
Another Superior **MOLONEY** *Product* ----

LOAD TAP CHANGERS

"M" SERIES LOAD TAP CHANGERS USED ON MOLONEY STEP VOLTAGE REGULATORS, POWER REGULATING TRANSFORMERS AND LOAD RATIO CONTROL TRANSFORMERS INCORPORATE REACTOR BY-PASS SWITCHING

SWITCHING REACTOR LOSSES ARE *ENTIRELY ELIMINATED* ON VOLTAGE REGULATING APPARATUS WHEN REGULATION IN 1¼% STEPS IS USED

Moloney "M" Series Load Tap Changers are provided on Load Ratio Control Transformers, Power Regulating Transformers, and medium and large ratings of Step Voltage Regulators. A separate switch is used for breaking load current, a feature heretofore supplied on only the very large ratings of regulating apparatus. The design of this switch and the timing of its operation in conjunction with the Tap Selector Switch, are such that the Switching Reactor is by-passed in *all* operating positions on 1¼% step apparatus and in *half* of the positions on ⅝% step apparatus. Since no current flows through the reactor when it is by-passed, there are no reactor losses. How by-passing is accomplished and the sequence of operations in changing from one tap position to another, is illustrated on the opposite page.



Moloney three-phase Load Tap Changer with automatic controls. Top assembly contains Tap Selector Switch, Load Transfer Switches and Reversing Switch. Motor drive and auxiliary equipment are at lower right. Automatic controls are at lower left. Moloney Automatic Control equipment features a supersensitive voltage regulating relay and an electronic time delay circuit. A complete line of remote-manual and automatic controls and associated equipment is available.

The Tap Selector Switch on Moloney Load Tap Changers does not have to perform the dual function of breaking current and changing taps. A separate Load Transfer Switch (upper left) makes and breaks the circuit, eliminating all arcing duty from the Tap Selector Switch (bottom), and making it possible to use longer arc clearances and highly accelerated breaker opening and closing speeds, with consequent increase in interrupting capacity. Reversing Switch at upper right.

Write for Bulletin No. LTC-901 describing the Moloney Load Tap Changer with Automatic Controls.

ME50-1

MOLONEY ELECTRIC COMPANY

Sales Offices in all Principal Cities

FACTORIES AT ST. LOUIS 20, MO. AND TORONTO, ONT., CANADA

(*Continued from page 26A*)

Any additional information on the meter may be obtained from the General Electric Company, Schenectady 5, N. Y.

Electrolytic Capacitors for Continuous Duty. Sprague Electric Company, North Adams, Mass., has announced a line of a-c electrolytic capacitors for 115-volt continuous a-c service. Known as Sprague type *11A*, these capacitors are best suited for across-the-line power factor improvement, as low voltages, particularly with appliances and light industrial equipment. Another use for the capacitors is in applications where a voltage drop is required without power dissipation. Sprague engineering bulletin *301*, available on request, gives complete standard ratings on this line of capacitors.

Rectifier- and Dual-Operated Insulation Testers. To meet the needs of industry for laboratory, production, and other repetitive field tests of insulation resistance, the James G. Biddle Company has developed two new models of their "Meg" type instruments: a rectifier-operated or plug-in model in which a transformer and rectifier are built into the same case with a "Meg" type ohmmeter; and a dual-operated model, which can be operated either by hand or by plug connection from a separate rectifier unit. In the rectifier-operated instrument, the hand generator is replaced by "power pack," consisting of a constant-voltage step-up transformer and selenium rectifier, giving a constant d-c test voltage. This constant voltage feature of the instrument reduces undesirable pointer fluctuations which may occur when testing equipment such as large generators and long cables having appreciable capacitance. The new dual-operated "Megger" insulation tester is available in a combination hand-crank and rectifier-operated set, which consists of the "Meg" type constant-pressure test set and a separate rectifier which supplies 500 volts direct current from any 115 volts alternating current, 60 cycles outlet. One cord from the hand-crank instrument and another from the rectifier to an a-c outlet eliminates hand operation. Complete information on these instruments may be obtained by requesting bulletin *21–46–7* from the James G. Biddle Company, 1316 Arch Street, Philadelphia 7, Pa.

Resistor Assortments. Ohmite Manufacturing Company, 4835 Flournoy Street, Chicago 44, Ill., has announced a complete line of larger industrial resistor assortments, packed in plastic cabinets. Resistance values in each assortment cover the complete Radio Manufacturers Association range in either plus or minus five per cent or plus or minus ten per cent tolerance. A choice of one-half, one, two, or assorted wattage sizes, in quantities from 510 to 2,025 are offered. The Ohmite Company will furnish any further details.

Dry-Type Lighting Transformers. A redesigned line of dry-type general-purpose lighting transformers which permit greater

(*Continued on page 36A*)

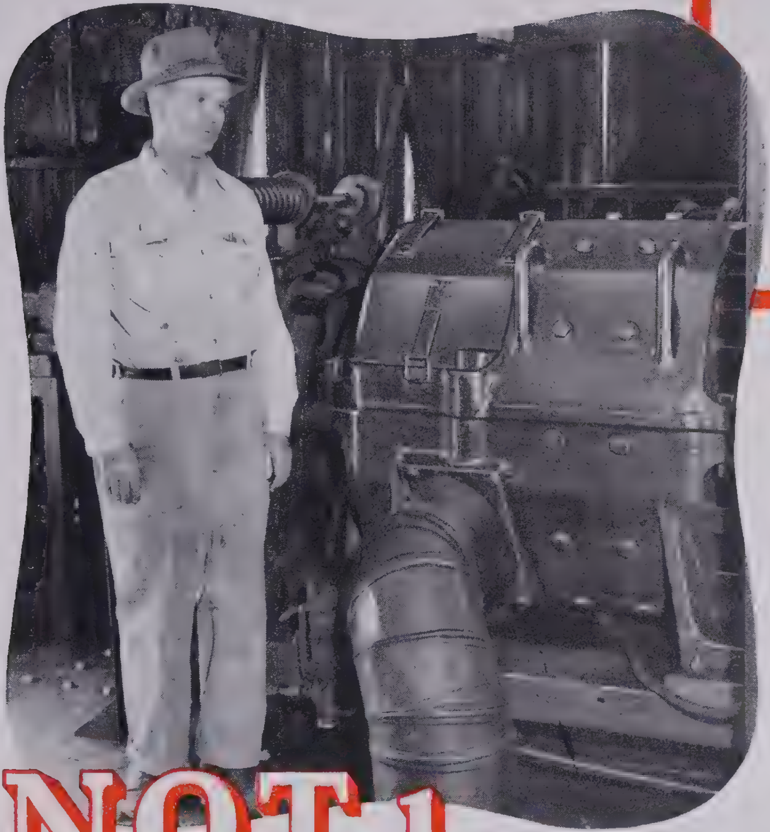
are **coil failures** *costing you money?*

look at this record!

18 *failures in 8 years with regular insulation*

Date and Cause of Failure

2/21/40	Armature coils grounded
12/29/40	Armature coils grounded
9/2/41	Open armature circuit
4/13/42	Armature coils grounded
4/18/42	Leads loose in commutator
10/24/42	Armature band thrown
4/5/43	Armature coils grounded
8/9/43	Open armature circuit
10/7/43	Armature coils grounded
9/30/44	Armature coils grounded
10/18/44	Armature coils grounded
7/28/45	Armature coils grounded
9/14/46	Armature coils grounded
2/6/47	Armature coils grounded
6/23/47	Armature coils grounded
9/17/47	Armature coils grounded
11/4/47	Armature band thrown
12/26/47	Armature coils grounded



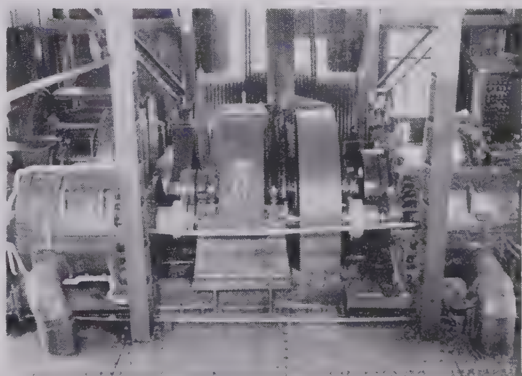
NOT 1 coil failure in 2 years with National special class H coils

"Still operating beautifully," is the report *two years after installation* on the National silicone-glass-mica armature coils of the motor shown above. They were installed January 7, 1948, in the National shop. That's quite a record, following the 18 failures in 8 years listed at the right above.

The motor is, of necessity, subjected to terrific abuse, since it is a hoist motor on a huge coal stripping shovel which often bites into solid rock. Excess heat burned out the coils monotonously . . . until National installed the special coils.

Special National Class H coils such as these are building up amazing records wherever high heat is a problem. They utilize silicone, melamine, glass, mica, MICA-CLAS, high-heat varnishes, special solders and other inorganic materials. The insulating materials are made in our plant to our rigid specifications. And all National coils fit snug and tight. They last.

Many armature burn-outs can be avoided by the use of higher grades of insulation. However, all-inorganic insulation isn't always the entire answer. Improved ventilation, better heat conductivity and other factors are also of importance. Your nearby National Field Engineer knows. Write for his name.



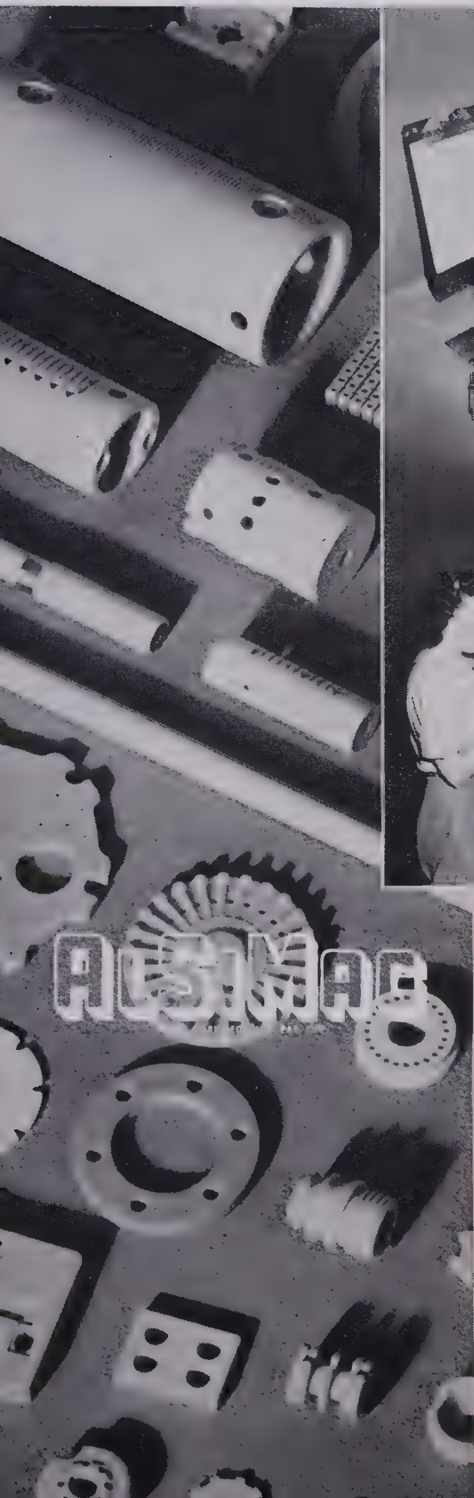
Part of the interior of the strip shovel is shown above. The motor outlined is the one which caused so much trouble and expense before National special Class H coils were installed. A larger view of the same motor is shown in the photo at the upper left.

NATIONAL ELECTRIC COIL COMPANY

★ COLUMBUS 16, OHIO, U. S. A. ★

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION— REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

TRADE MARK


ALSIMAG

(*Continued from page 32A*)

circulation of air through and around the transformer, resulting in lower operating temperatures, is being manufactured by the Marcus Transformer Company, Inc. The built-in wiring compartment has been enlarged and the amount of available knock-outs have been increased to facilitate the wiring of either an individual transformer or three units used in a 3-phase self-contained bank. The line, designated as type *C*, is available in ratings of 480/240 - 120/240, up to and including 15 kva, as well as 3-phase ratings of 240 or 480 on the primary, and 120/208Y, four wire on the secondary. Any further information on the transformers may be obtained from the company at 32–34 Montgomery Street, Hillside 5, N. J.

Combination Arrester and Fuse Cutout. Line Material Company's new combination expulsion arrester and open link fuse cutout has been designed primarily for low-cost protection of conventional distribution transformers on rural lines with ratings of 7,200/12,470 and 7,620/13,200 volts, grounded Y. The arrester provides low impulse sparkover voltage and high discharge current characteristics, and the cutout features a 6-petticoat wet-process porcelain insulator, assuring a firm-wedge friction fuse link contact and maximum current-carrying capacity at all times. The Line Material Company, at Milwaukee 1, Wis., will furnish any additional details upon request.

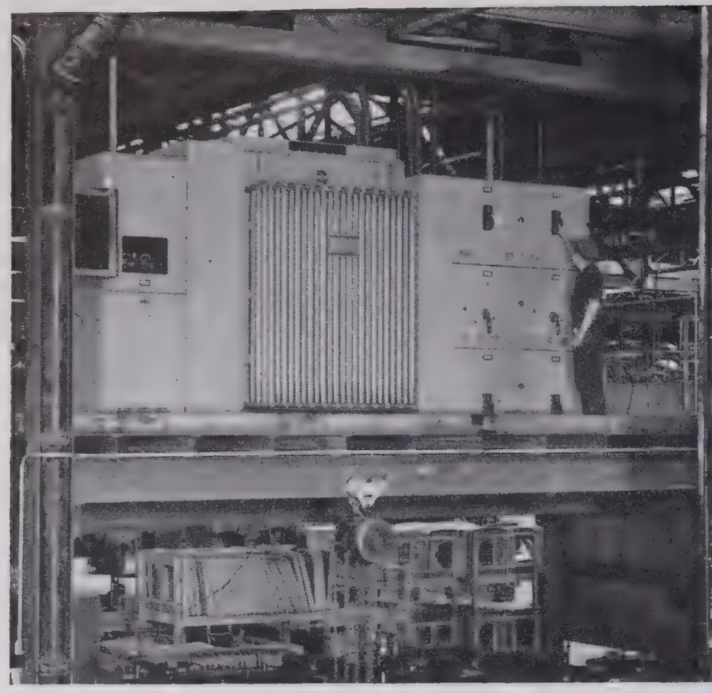
TRADE LITERATURE

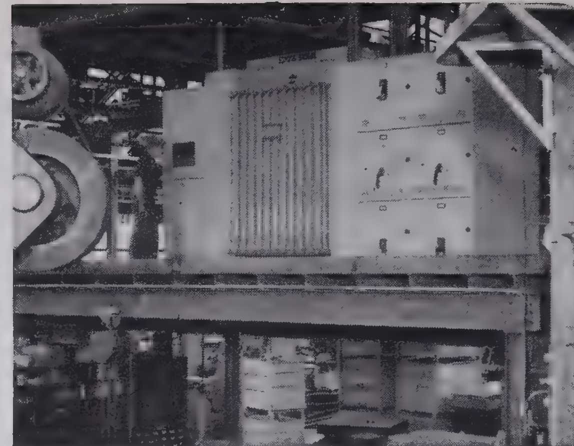
Laboratory Standards. The Measurements Corporation, Boonton, N. J., has published a 44-page catalog, "Laboratory Standards," which presents the complete line of standard signal generators, television signal generators, pulse generators square wave generators, megacycle meters, vacuum tube voltmeters and other laboratory instruments manufactured by the company. Copies may be obtained by writing to Measurements Corporation for catalog *C*.

Planned Street Lighting. "Planned Street Lighting for Public Safety" (*B-4332*), is the title of a 28-page illustrated booklet available from the Westinghouse Electric Corporation. The booklet is divided into three parts: the problem of public safety lighting; factors that effect street lighting (night visibility, sight-distance, reflection and glare); and planning a street lighting program. The booklet may be obtained by writing directly to the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

The Oscillographer. "The Oscillographer" is a publication devoted exclusively to the cathode-ray oscillograph, providing the latest information on developments in equipment, applications and techniques. It is available from the

(*Continued on page 40A*)





ALL UNIT SUBSTATIONS MOUNTED ON PLATFORMS TO SAVE FLOOR SPACE

Two views of General Electric 1000-kva load-center unit substation at new Maytag plant. Valuable manufacturing space is saved by locating units on platforms under the roof, right over the center of the load area. Air switch on primary is easy to operate, contacts are easy to see. Air circuit breakers on secondary are of the drawout type, easily removable for inspection and maintenance. Note entire load center is metal enclosed, thus offering operating safety to personnel.

LOAD-CENTER
GE UNIT SUBSTATIONS

Unit substation No. 5, rated 500 kva. Air circuit breaker for future circuit can be inserted in empty upper housing. Drawout breakers are G-E Type AK-1 with 25,000 ampere interrupting rating—plenty of "IC" (Interrupting Capacity) to handle all short circuits. Contacts of 5 kv air switch are clearly visible through window, another safety feature of G-E substations.

G-E 5-kv metal-clad switchgear handles 4160 volts incoming power, distributes it to six load-center unit substations where it is stepped down to 480 volts for utilization. Metal-clad switchgear is neat in appearance, saving in space, and offers safety to operating personnel. Additional sections can be added for future expansion with a minimum of bother and expense.

(Continued from page 36A)

Allen B. Du Mont Laboratories, Inc., Instrument Division, 1000 Main Avenue, Clifton, N. J., upon request.

Electrical Insulation Price Catalog. The Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill., has issued a new 128-page price catalog, number *14,* which contains complete price information on electrical insulating materials. Copies are available from the Advertising Department of the company.

Instrument News. The first issue of "Perkin-Elmer Instrument News for Science and Industry" has been released. It is devoted exclusively to the use of modern electro-optical instruments in industry, such as the infrared analyzer, the flame photometer, and the Tiselius electrophoresis apparatus. Copies of the publication may be obtained from The Perkin-Elmer Corporation at Glenbrook, Conn.

Plaskon Handbook. The Plaskon Division of the Libbey-Owens-Ford Glass Company, 2112–24 Sylvan Avenue, Toledo 6, Ohio, has published a 58-page, four color booklet which discusses the properties, applications, and techniques of molding Plaskon urea and melamine molding compounds. The handbook and other literature on plaskon and alkyd plastics is available upon request to the company.

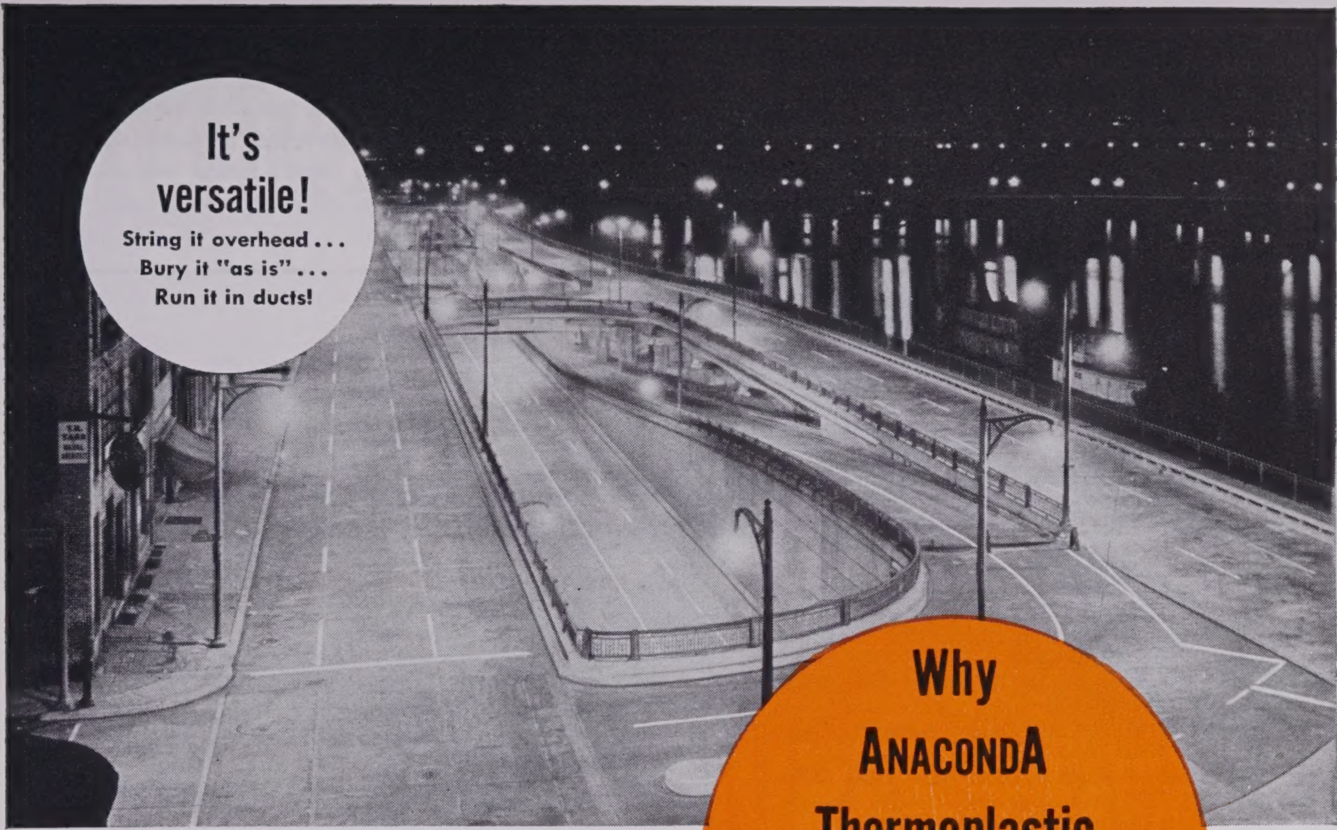
Vinyl Butyral Resins. The Bakelite Corporation has issued a new booklet—"Vinylite—Vinyl Butyral Resins," which contains a complete description of all the general properties of vinylite vinyl butyral resins, which are used for safety glass laminants, and for use in coatings and adhesives. The booklet may be obtained from the Bakelite Corporation at 300 Madison Avenue, New York 17, N. Y.

Tenite Injection Molding. A procedural guide to the injection molding of Tenite I and Tenite II, Eastman cellulose acetate and cellulose acetate butyrate thermoplastics, has been published in an enlarged edition by the Tennessee Eastman Corporation. The 55-page book, entitled "Tenite Injection Molding," contains detailed data on choice of material, proper product design, injection-molding machines, mold design and construction, and various finishing operations. Copies of this edition (third) are available from the corporation at Kingsport, Tennessee.

Linear Variable Differential Transformer Notes. Schaevitz Engineering, Crescent Boulevard at Drexel Avenue, Pennsauken Township, Camden 11, N. J., has published a bulletin, "Notes on Linear Variable Differential Transformers," which may be obtained upon request.

Electric Heater Catalog. All types of standard Chromalox heating units are listed in the new Chromalox catalog of industrial electric units, number *50,* which

(Continued on page 46A)



Why ANACONDA Thermoplastic Street Lighting Cable is *Safer*

For public safety (and good will) street lighting service must not fail. ANACONDA Thermoplastic Street Lighting Cable is:

Safer because it is stubbornly resistant to sun and weather when overhead . . .

Safer because it is ruggedly resistant to earth acids and alkalies when buried . . .

Safer because its tough hide resists abrasion and cutting when pulled into duct . . .

Safer because it is moisture-resistant and flame-retardant.

ANACONDA Thermoplastic Street Lighting Cable is available insulated with either Densheath* (vinyl resin) or polyethylene for 3,000 and 5,000 volts; with or without lead sheath.

Polyethylene may be jacketed with tough, mechanically-protective Densheath, or with flame-retardant, non-combustible ANACONDA Type FR** Compound. The latter has superior insulating properties. For complete information get in touch with your nearest Anaconda Sales Office or Anaconda distributor. Anaconda Wire & Cable Company, 25 Broadway, New York 4, New York.

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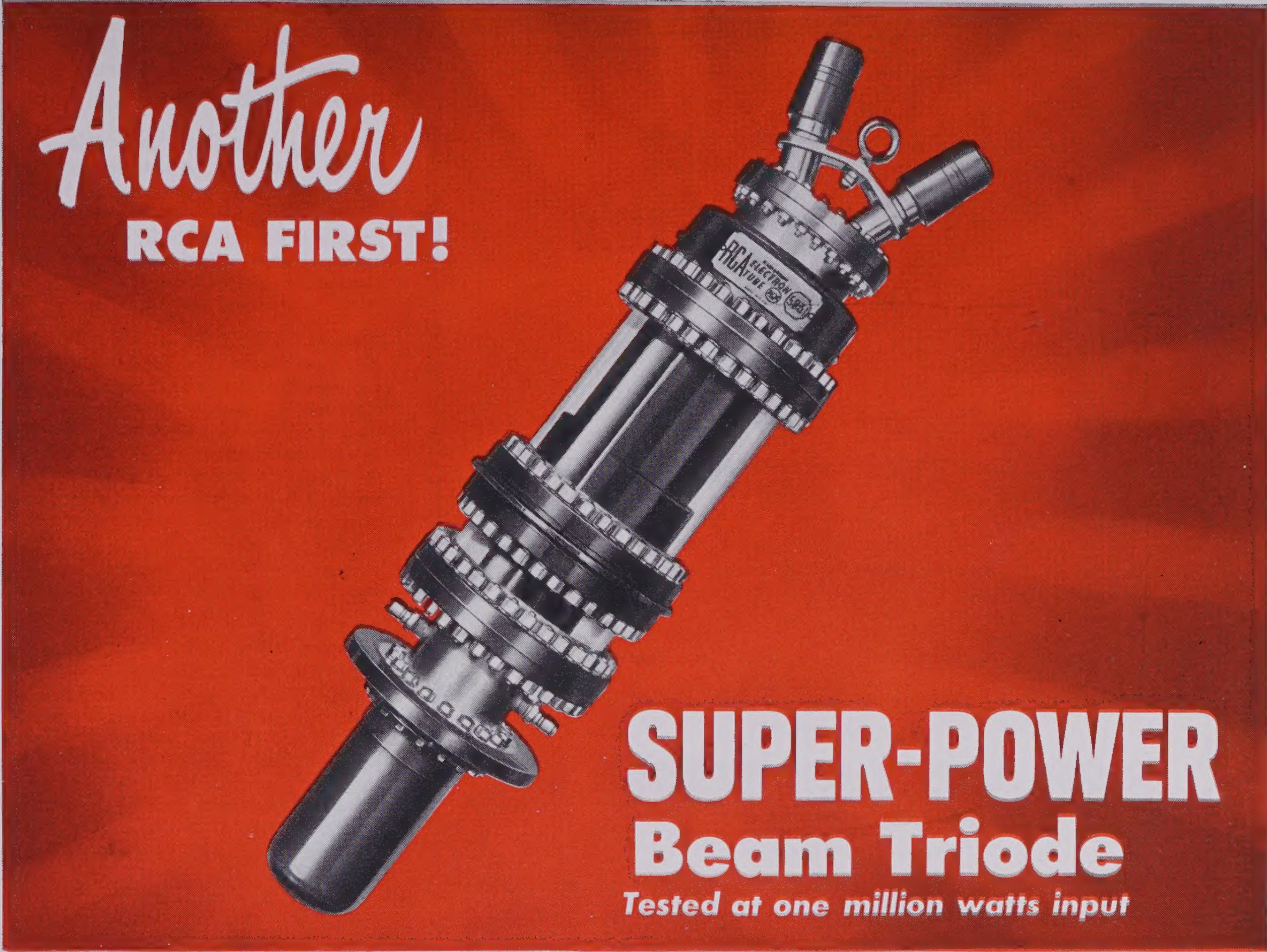
*Reg. U. S. Pat. Off.
**Trademark

The right cable for the job ANACONDA®

WIRE AND CABLE



The Fountainhead of Modern Tube Development is RCA

The new RCA-5831 has a conservative 500-kw output* with less than 2-kw grid drive!

IMAGINE A TUBE just a shade over 38 inches long and 9 inches in diameter that handles with high efficiency an input of 650 kilowatts* in continuous commercial service . . . that, then, is the new and revolutionary RCA-5831 super-power *beam triode* —tipping the scales at a mere 135 pounds!

This new tube can be operated with maximum rated plate voltage and plate input at frequencies up through the AM broadcast band and much higher. The limitations for operation at the higher frequencies have not yet been determined, but we will welcome requests for information on specific applications.

The RCA-5831 is unique in that it features a symmetrical array of unit electron-optical systems embodying a mechanical structure which permits close spacing and accurate alignment of the electrodes to a degree unusual in high power tubes. Ducts for water-cooling the plate and beam-forming cylinder are built-in and have simplified hose connections. The grid-terminal flange employs a water-cooled connector. Because of the electron-optical principles incorporated in its design, the 5831 has low grid current and hence requires unusually low driving power.

Other features of the RCA-5831 include a multi-strand, thoriated-tungsten filament for economical operation as well as high emission capability, and low-inductance rf leads and flange terminals.

A technical bulletin covering the RCA-5831 in more detail, is available from RCA Commercial Engineering, Section C39R Harrison, N. J. ***Unmodulated class C service**

ANOTHER new RCA tube . . .

. . . the RCA-5675 "Pencil-Type" Triode for UHF applications: RCA-5675 is a new medium-mu triode employing a double-ended coaxial-electrode structure, for use in grounded-grid circuits. As a local oscillator, it will deliver a power output of 475 milliwatts at 1700 Mc. and about 50 milliwatts at 3000 Mc.

See the new RCA-5831 at the RCA Exhibit, I.R.E. National Convention, Grand Central Palace, N.Y.C., March 6-9.

RADIO CORPORATION of AMERICA
ELECTRON TUBES **HARRISON, N. J.**

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is available by writing to the Edwin L. Wiegand Company, 7500 Thomas Boulevard, Pittsburgh 8, Pa.

Centrifugal Blowers and Exhausters. Bulletin *120-B-14*, issued by the Roots-Connersville Blower Corporation, 900 West Mount Street, Connersville, Ind., contains complete descriptions of the company's centrifugal blowers and exhausters, and is obtainable upon request.

Electric Cable, Wire, and Conduit Data. The Triangle Conduit and Cable Company has published an 86-page catalog, number *500*, which provides extensive technical data on electrical cable, building wire, and conduit raceways, as well as information on electrical engineering and wiring standards for the aid of contractors, engineers, architects and industrial users. Requests for catalog *500* should be sent to the Triangle Conduit and Cable Company, Inc., 1937 Jersey Avenue, New Brunswick, N. J.

Contour Projector. The Industrial Optical Division, Eastman Kodak Company, Rochester 4, N. Y., has prepared a new eight-page booklet which describes the Kodak contour projector. Conventional shadow projection is illustrated together withsur face projection for inspecting blind holes and other dimensions that cannot be silhouetted. The booklet may be obtained without charge by writing to the company.

Small Motor Selector. A small motor selector is available from the Westinghouse Electric Corporation, which explains why there are different types of fractional horsepower motors, and the factors to be considered in selecting the right motor for the right application. The booklet, *B-3075-C*, will be furnished upon request to the corporation at Box 2099, Pittsburgh 30, Pa.

Electronic and Electrical Components. The Cambridge Thermionic Corporation has released its new catalog, number *300*, on electronic and electrical components. The 70 pages are subdivided into sections on terminal lugs, terminal boards, swagers, hardware, insulated units, and coils and chokes. The corporation, at 445 Concord Avenue, Cambridge 38, Mass., will furnish copies of the catalog upon request.

Guide to Ferrous Metallurgy. The Tempil Corporation, 132 West 22nd Street, New York 11, N. Y., has announced that a fourth printing of the Tempil "Basic Guide to Ferrous Metallurgy" is again available. This chart shows the working characteristics of steels in temperatures from minus 300 degrees Fahrenheit to 2,900 degrees Fahrenheit. All the important temperature zones and temperature ranges are shown, as well as a diagram which symbolizes the change in grain size with temperature. The plastic-laminated wall chart measures 16¼ inches wide by 21 inches long, and may be obtained by writing directly to the company.